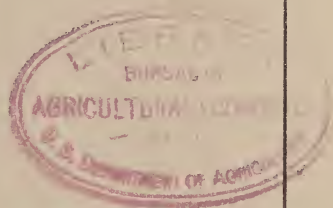


Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON
THE AGRICULTURAL EXPERIMENT
STATIONS, 1939



1
EX 6
1939

SEP 28 1940

PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS

OFFICE OF EXPERIMENT STATIONS

JAMES T. JARDINE, Chief
R. W. TRULLINGER, Assistant Chief

ADMINISTRATION OF GRANTS TO STATES AND COORDINATION OF RESEARCH

J. T. JARDINE, R. W. TRULLINGER, H. P. BARSS, E. C. ELTING, F. D. FROMME,
G. HAINES, F. G. HARDEN, H. W. MARSTON, J. I. SCHULTE, SYBIL L. SMITH,
H. M. STEECE, J. W. WELLINGTON, R. Y. WINTERS, B. YOUNGBLOOD

DIVISION OF INSULAR STATIONS

JAMES T. JARDINE, Chief

Puerto Rico: ATHERTON LEE, Director.

CONTRIBUTORS TO THIS REPORT

Agricultural Economics—F. G. HARDEN.

Agricultural Engineering—R. W. TRULLINGER.

Agricultural Soils and Plant Nutrition—H. C. WATERMAN.

Animal Production, Products, Diseases, and Disorders—H. W. MARSTON, G. HAINES,
E. C. ELTING, and W. A. HOOKER.

Field Crops, Pastures and Ranges, and Weed Control—H. M. STEECE.

Consumer and Family Problems—SYBIL L. SMITH.

Horticulture and Forestry—J. W. WELLINGTON.

Plant Diseases and Insect Pests—H. P. BARSS and F. V. RAND.

Rural Sociology—B. YOUNGBLOOD.

Statistics—F. G. HARDEN.

Manuscript Supervision—KATHARINE A. NAU.

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF EXPERIMENT STATIONS

Washington, D. C.

June 1940

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1939

By J. T. JARDINE and F. D. FROMME ¹

CONTENTS

	Page		Page
Introduction.....	1	Progress of agricultural and rural life research—	
The coordination of agricultural research.....	2	Continued.....	
Administrative aids to coordination.....	2	Animal production, products, etc.—Con.	
Bankhead-Jones regional laboratories.....	3	Genetics.....	154
Special research fund projects.....	4	Physiology.....	160
Utilization-of-farm-products regional laboratories.....	4	Animal diseases and disorders.....	163
Examples of coordinated research.....	5	Agricultural engineering.....	172
Progress of agricultural and rural life research.....	7	Consumer and family problems.....	183
Plant production, products, diseases, and insect pests.....	7	Rural social science.....	219
Field crops, pastures and ranges, and weed control.....	7	Agricultural economics.....	220
Horticulture and forestry.....	43	Rural sociology.....	233
Agricultural soils and plant nutrition.....	67	Statistics of the experiment stations.....	245
Plant diseases and insect pests.....	81	Personnel and publications.....	245
Animal production, products, diseases, and disorders.....	129	Income.....	245
Nutrition, management, and products.....	130	Expenditures.....	246
		Additions to equipment.....	246
		Disbursements of Federal-grant funds.....	247
		Statistical tables.....	248

INTRODUCTION

During the year ended June 30, 1939, the research work of the agricultural experiment stations resulted in many new and significant contributions to the improvement of agriculture and rural life. The printed record of these studies, embracing more than 46,000 pages in station publications and scientific journals, reported progress and conclusions on some 8,500 research projects.

The direct support for these extensive programs of investigation was derived from Federal, State, and supplemental sources and amounted to \$20,622,758.61. Approximately one-third (\$6,541,250) was derived from Federal-grant funds authorized by the Hatch, Adams, Purnell, title I of the Bankhead-Jones Act of June 29, 1935, and supplemental acts, and two-thirds (\$14,081,508.61) from State appropriations and supplemental income derived from endowments, fellowships, fees, sales, and other sources.

In addition to these direct sources of support, the research work of the experiment stations was aided and augmented by coopera-

¹ With the collaboration of other members of the Office staff.

tion with the Department of Agriculture. Approximately 1,000 projects conducted in cooperation with bureaus of the Department under some 1,400 formal memoranda of understanding received support from Department as well as station funds. Information derived from Department investigations likewise contributed to the progress of much of the station work not covered by formal cooperative memoranda of understanding. In like measure and manner the work of the stations contributed to the progress of Department studies. The coordination of State and Federal research has been effected to such an extent that a recital of the accomplishments by either the State agricultural experiment stations or the United States Department of Agriculture would in most instances involve acknowledgment of active cooperation of the other agency or of aid in the way of information leading to the solution of problems.

Cooperative relations between the Department and the stations are built upon the understanding that cooperation is a matter of mutual helpfulness, working together to a common end, rather than one of financing. In specific undertakings each agency contributes what it can to the planning, conduct, and interpretation of the work, and furnishes such facilities and funds as is practicable. While both agencies are interested in fundamental research, the Department is concerned primarily with results having regional and national application and the stations with results having local application.

The pooling of resources of men and facilities in these cooperative undertakings has contributed to economy of effort and expenditures, helped to avoid unnecessary duplication and waste, and expedited solution of problems.

Interstation cooperation is also an important element in the close integration that exists in agricultural research in the United States. Much helpful teamwork on problems of mutual interest is in effect between neighboring stations or groups. No estimates of the extent of these relations have been attempted since they are often conducted in an informal way without written memoranda or joint project outlines.

THE COORDINATION OF AGRICULTURAL RESEARCH

ADMINISTRATIVE AIDS TO COORDINATION

In 1939, as formerly, the Office of Experiment Stations acted as a central agency to promote cooperation in the planning and conduct of research between the stations and the Department. As Director of Research, the Chief of the Office also performed a similar function with respect to research work within the Department.

The coordination of the research of the Department and that of the experiment stations was furthered on the one hand by assisting the stations to obtain scientific advice and suggestions, as well as active cooperative help from the Department, and on the other by assisting agencies of the Department to develop the most effective cooperation with one or more stations.

During the year the Office examined and approved 344 new and 122 revised project outlines submitted by the stations for proposed Federal-fund expenditures. Each of these was considered as to possibilities for coordination and cooperation with research along similar lines in other stations or in the Department, and desirable agreements

or other types of assistance were effected in many instances. The stations had under investigation 523 Adams projects, 1,680 Purnell projects, and 818 Bankhead-Jones projects in 1939, including new and revised outlines, or a total of 3,021 projects financed wholly or in part from Federal-grant funds. Comparable numbers of projects active in 1938 were 505, 1,660, and 695 for the 3 funds, respectively, a total of 2,860. During the year 45 Adams, 223 Purnell, and 39 Bankhead-Jones projects were completed. In all there were approximately 8,500 projects active in the 50 State stations and the Alaska, Hawaii, and Puerto Rico stations, including those supported solely from State and supplemental funds. Opportunities for furthering cooperative relations with respect to many projects, in addition to the new and revised Federal-fund projects, were afforded during the annual visits to the stations by representatives of the Office.

The administration of the special research fund authorized by the Bankhead-Jones Act of June 29, 1935, for the use of the Department also permitted the Office to contribute material aid in the promotion of cooperative relations, especially through the nine regional research laboratories established under provisions of this act in the major agricultural regions. Each has been planned in cooperation with the State experiment stations to provide for joint Federal-State investigation of major problems basic to agriculture in broad aspects.

BANKHEAD-JONES REGIONAL LABORATORIES

Each of the nine laboratories established under the Bankhead-Jones Act has a distinctive research program of major importance to the region that it serves. Each functions as a coordinating agency for the research of the Department and that of the stations in the field of its research program. For example, the improvement of vegetable crops for the Southeastern States is being advanced through cooperation between the Department and 13 Southeastern State stations, the work of the laboratory being centralized at Charleston, S. C. The laboratory gives emphasis to determining the principles underlying the inheritance of desired characteristics among the kinds of vegetables selected for study and creates and distributes stocks having these characteristics from which the State collaborators through further work may select and improve the strains that prove best adapted to their conditions. The State collaborators meet at least once a year with representatives of the Office of Experiment Stations and the bureau or bureaus having supervision of the work of the laboratory, and review with the director and staff of the laboratory the work accomplished and the program for the ensuing year.

Similar coordination of State and Federal research has been effective for one or more years in the improvement of pastures for the Northeastern States at the regional laboratory at State College, Pa.; in research on the development of industrial uses for soybeans and soybean products in the regional laboratory at Urbana, Ill., for the North Central region; in the improvement of swine through breeding at Ames, Iowa, where the regional laboratory program is organized in cooperation with 12 North Central States and Oklahoma; and in the improvement of sheep through breeding for 12 Western range States, which cooperate with the Department in the work of the regional laboratory at Dubois, Idaho. Cooperative research on diseases of

domestic animals and poultry, directed toward the control of contagious, infectious, and parasitic diseases in 13 Southeastern States, was begun in 1937 in the regional laboratory at Auburn, Ala. More recently research programs for the improvement of viability in poultry and for acquiring basic information on problems related to the salinity of irrigation waters have been established in regional laboratories at East Lansing, Mich., and Riverside, Calif., respectively. The cooperating stations in the first instance represent 13 North Central and 12 Northeastern States and in the latter 11 Western States and Hawaii.

The most recent of the nine regional research laboratories was established in 1939 at Cornell University for research on the relation of soils to plant, animal, and human nutrition. Although sponsored primarily by the experiment stations of the Northeastern States, the investigations of this laboratory are national in scope. A group of collaborators, composed of outstanding investigators in the fields of soil science, and plant, human, and animal nutrition, will advise relative to the program and conduct of the investigations. The program of the laboratory reflects a widespread interest in the effects of mineral elements of the soil derived through the medium of plants used as food and the effects of various growth substances upon the dietary reactions and the behavior and development of animals and man.

SPECIAL RESEARCH FUND PROJECTS

The portion of the special research fund available for special research projects directed primarily to studies basic to agriculture in its broadest aspects was also used to an appreciable degree in investigations carried on in cooperation with the experiment stations and other institutions. In accordance with the provisions of the Bankhead-Jones Act the carefully outlined projects, when approved by the Secretary, are assigned for leadership to the subject-matter bureau most directly concerned, with provision for cooperation with other bureaus of the Department, State experiment stations, and other research agencies having personnel and facilities which may contribute effectively to the solution of the problems involved. The extent of this cooperation is shown by the fact that 11 bureaus, 24 State experiment stations, and 16 other agencies participated in special research project work in 1939. Typical of cooperative research into broad regional or national problems under this fund is the investigation of farm storage of corn. This study, which has been in progress for 2 years, involves the work of 5 Department bureaus and 4 State experiment stations.

UTILIZATION-OF-FARM-PRODUCTS REGIONAL LABORATORIES

Under the provisions of section 202 of the Agricultural Adjustment Act of 1938, the Secretary of Agriculture was authorized—

to establish, equip, and maintain four regional research laboratories, one in each major farm producing area, and, at such laboratories, to conduct researches into and to develop new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities.

A survey "to determine the location of said laboratories and the scope of the investigations to be made and to coordinate the research work now being carried on," as authorized by the Agricultural Appro-

priation Act for 1939, was conducted during the year. Research objectives for the laboratories were considered jointly by representatives of research agencies of the four regions and the Department; related research in the Department and other Federal agencies, the State experiment stations, educational institutions, privately endowed research institutions, consulting laboratories, and industrial laboratories was recorded and analyzed; facts bearing upon the advantages of several hundred proposed laboratory locations were assembled; and consideration was given to principles of coordinating the research of the laboratories with each other, and with active work in the Department and elsewhere.

As finally determined, the laboratories were located at Wyndmoor, Pa., for the eastern region; Peoria, Ill., for the northern region; New Orleans, La., for the southern region; and Albany, Calif., for the western region.

The need for continued interest and cooperation of the best technical thought within the Department and throughout related interests in the Nation is given an important place in planning the laboratory programs, and many opportunities for furthering Department and station cooperation will doubtless be afforded during the active work of investigation.

EXAMPLES OF COORDINATED RESEARCH

The national study of adjustments in farming by regions and type-of-farming areas, begun during previous years on an emergency basis, was continued in 1939 in 26 States with the cooperation of the Agricultural Adjustment Administration, Bureau of Agricultural Economics, Farm Security Administration, and Soil Conservation Service. It has now been completed in 22 States, 9 having finished the study during the year. The coordinated efforts of the State agricultural experiment stations and the Department to meet long-time requirements of a permanently adjusted agriculture have now been refocused to include agricultural adjustment, conservation, crop insurance, farm forestry, flood control, water utilization, land retirement, rehabilitation, and other factors that affect land use. The new program will involve the cooperation of farmers, State extension services and experiment stations, the Bureau of Agricultural Economics, and action and operating agencies of the Department. By the end of the year 28 States had signed formal cooperative documents covering the new undertaking.

Cooperative research in various phases of soil conservation under an over-all memorandum of understanding was in effect between 47 State experiment stations and the Soil Conservation Service. Specific studies active during the year under this broad program of research included studies to determine the economic and social effects on farms resulting from a definitely planned program of soil conservation in which 17 States cooperated with the Soil Conservation Service and the Bureau of Agricultural Economics, hydrological investigations, and studies dealing with other phases of erosion control.

The cooperative efforts at crop improvement and in the development of cost-saving production methods were continued and focused along the more productive lines indicated by previous studies. The cereal-crop improvement investigations again included 21 States, the coop-

erative breeding and cultural studies of potatoes 22 States, and the corn-improvement, forage-crop, and grass breeding and improvement investigations involved 7, 10, and 11 stations, respectively. The investigations on production, improvement, and diseases of cotton were continued in 12 States. Cooperative investigations of machinery for the mechanical application of fertilizers to cotton, sugar beets, and canning crops, also for the production and harvesting of sugar beets, corn, and cotton, and for the control of weeds were continued in 11 States. The cooperative soil survey was active in 28 States during the year. Investigations of concentrated fertilizers involved 11 States and 2 bureaus of the Department. Investigations of parasites of the oriental fruit moth were extended to 12 stations. Cooperative work on cereal and forage-crop insects was continued in 9 States.

The cooperative western-range-survey agreement, covering 7 regions and involving 14 State stations, 4 Department bureaus, and the Division of Grazing and the Bureau of Indian Affairs of the Department of the Interior, was renewed for various periods with the different stations. The study of input as related to output in milk production was continued with 2 Department bureaus and 10 State stations cooperating. The estimate of farm population and of farm-population movements was extended to 13 States, and the study of quality and palatability of meat was continued in 9 States.

The several regional cooperative projects which deal with the nutritional well-being of young women of college age reflect increasing recognition of the importance of good nutrition to health and of the need for more satisfactory standards for optimum nutrition. The project on the nutritional status of college women, in which experiment stations in six North Central States are cooperating, entered the fourth year of the 5-year plan with an accumulation of data on anthropometric measurements, basal metabolism, formed elements of the blood, and dietary balances sufficient to warrant preliminary analyses. No one institution could have accumulated sufficient data in this length of time to warrant the general treatment of the pooled data now possible. The advantages inherent in coordinated research are also becoming evident in the regional project on ascorbic acid metabolism, which has completed its second year as a cooperative project participated in by five stations in the Northwest. Here, identical methods are being followed in a survey of the ascorbic acid metabolism of college students on their customary diet, and in addition each station has been assigned a particular problem in methodology on which to concentrate and report at the annual conference of project leaders. A similar though less extensive project in the Northeast, in which three Northeastern States are cooperating, is effectively coordinated with the work in the Northwest by the fact that the same methods of determining the saturation requirements for vitamin C are used in both regions. General conclusions concerning the vitamin C requirements of this age group will be established with less effort and in a shorter time because of the data accumulated jointly by the workers of the two regions.

A further example of coordinated research of interest to consumers generally is that of the study of performance during wear of fabrics used in women's and children's garments. Experiment stations in six Northeastern States are participating in this study which has completed its third year. To date about 700 fabrics have been analyzed

and a few of the worn-out garments have been inspected. This project is providing a means of assembling a large amount of data on the types of fabrics on the market and the value of laboratory tests as a means of predicting their actual wear in women's and children's garments. Within 2 years sufficient analyses have been made to supply the Federal Trade Commission with data helpful in the establishment of trade-practice rulings concerning properties of woven cotton and rayon fabrics.

Cooperation between the Department and various groups of experiment stations was also in progress in numerous other regional and national studies of a long-time character. The total number of formal agreements covering cooperative research ranged from 9 to 59 per station.

PROGRESS OF AGRICULTURAL AND RURAL LIFE RESEARCH

The summary of the progress made in experiment station research in 1939, which follows, is based on the publications issued during the year by the 50 State stations, the Alaska, Hawaii, and Puerto Rico stations, and the Federal Puerto Rico station. The review of the printed record has also been supplemented by special reports of significant accomplishments from the directors of these stations.

Since, as stated earlier, the publications of the experiment stations in 1939 comprised more than 46,000 pages, this summary does not attempt to report all of the research projects active during the year and is necessarily quite incomplete as to details of the experimental work accomplished and the results obtained in the investigations that are reported. These have been selected within the several fields so as to depict the wide range of the subjects studied and the findings having greatest significance in the solution of current problems. They reflect a decided trend in experiment station research directed to meet local and national long-time as well as present needs for greater agricultural stability and permanency, and promote the highest possible standards of living and health.

PLANT PRODUCTION, PRODUCTS, DISEASES, AND INSECT PESTS FIELD CROPS, PASTURES AND RANGES, AND WEED CONTROL

CONTENTS

	Page		Page
Cotton.....	8	Tobacco.....	23
Corn.....	11	Sugar crops.....	24
Wheat.....	13	Sorghum.....	26
Oats.....	16	Soybeans.....	26
Barley.....	17	Alfalfa.....	27
Rice.....	18	Clovers and other legumes.....	29
Flax.....	18	Grasses and hay.....	32
Potatoes.....	19	Pastures and ranges.....	36
Sweetpotatoes and other root crops.....	22	Weed control.....	40

Achievements were numerous in the agronomic research at the State experiment stations, which continued to deal with problems of variety, rotation, cultural methods, field practices, soil fertility, harvesting, and storage involved in the production, handling, and disposal of farm crops. Productive new strains and varieties of cotton,

hybrid corn, wheat, oats, rice, flax, potatoes, sweetpotatoes, sugar beets, sugarcane, grain sorghum, alfalfa, Sudan grass, and lawn-grasses, usually with superior qualities and often disease resistant, were brought forward by the stations, tested, and distributed. There were improvements in such production practices as the artificial drying of seed corn, seed treatments and timely irrigation of potatoes, storage of sweetpotatoes and hay, ways of growing soybeans to avoid soil erosion, the cutting of alfalfa for best yield and quality, and short, productive legume-grain rotations.

Efficiency in the use of plant foods was aided by the perfection of foliar (leaf) diagnosis of nutrient needs of corn and potatoes, proper placement of fertilizer for potatoes and beans, a physiological approach to tobacco fertilizer needs, and the devising of timely treatments for meadows, pastures, and lawn turfs. Quality of products was enhanced through findings in cotton-fiber studies, in milling and baking tests with wheat, in malting tests of barley varieties, on the merits of edible soybeans, by the timely harvesting of Havana seed tobacco, and the proper cutting of timothy and alfalfa. Curing research with burley tobacco and curing and storage studies with sweetpotatoes and hay also showed ways to improve products.

Criteria of progress in pasture research were improved management practices, responses in herbage production to lime and phosphorus, and the profitable use of supplementary pastures and of adapted mixtures. Range research showed ways to restore depleted ranges, to revegetate abandoned cropland, and to control range shrubs and weeds, and improvement in general. Weed research provided definite control measures for specific weeds by cultivation, and spraying brought out promising new herbicides, and better ways to use the practices and chemicals already available.

Examples of fundamental studies furnishing basic information for the development of more practical experiments were researches on cold and freezing resistance in wheat, hydrocyanic acid in sorghums, blooming in timothy according to latitude, temperature requirements of grasses and their responses to cutting and grazing, seed germination, root reserves in forage crops in relation to persistence and in bindweed in regard to control measures, and on the relation of soil texture and fertility to actions of herbicides and soil sterilizers.

These and other recent findings in research with field crops, pastures and ranges, and in weed control are discussed in detail in the following pages.

COTTON

Cotton research of the stations, usually in cooperation with the Department (B.P.I. and B.A.E.), was concerned with problems of improvement, cultural methods and field practices, fertilizers and nutrition, and harvesting and ginning. Typical examples given illustrate findings in research on fiber quality, fertility practices, and other phases.

Fiber quality.—Demands of domestic and foreign spinners for cotton fiber with longer, more uniform staple and higher quality have stimulated station research to these ends and better methods and products have resulted. New productive varieties characterized by longer lint or disease resistance were made available by the Louisiana and New Mexico stations, and other stations in cotton-growing States

were making rapid advances in this direction. Cotton inbred for 3 years by the Arkansas station was greatly improved in uniformity of plant and fiber characteristics, and hybrids between certain inbred lines were unusually promising. This procedure proved more effective and timesaving than previous methods.

Progress in cotton improvement has been aided greatly by improved mechanical devices for technological tests and by the recent determinations of the North Carolina and Arizona stations that certain plant and lint characters are associated with high spinning values. Mechanical equipment for combing and sorting fiber, employed in the cotton-research program of the Arkansas station, has permitted a nearly thirtyfold enlargement of the volume of work or the number of measurements that can be made. The devices include a fiber comber and a photoelectric cotton-fiber sorter, both for seed cotton. Fibrographs developed by the Tennessee station for measuring rapidly and accurately fiber lengths on ginned lint and single seeds are used extensively in its cotton research. Measurements made in this way have been found to be more accurate and are entirely free from the personal factor in hand work.

Remarkable progress made by North Carolina farmers in bettering the staple length of their cotton, i. e., from around twenty-nine thirty-seconds of an inch in 1928 to slightly more than 1 inch in 1936, was revealed by the North Carolina station, cooperating with the Department (B.A.E.). In 1928 about 80 percent of the crop stapled less than fifteen-sixteenths of an inch, while in 1936 only 13 percent was that short and 85 percent was between fifteen-sixteenths and $1\frac{1}{16}$ inches long, attributable to shifts to the longer-stapled varieties. The New Mexico station in like cooperation (B.A.E.) determined that 69.1 percent of New Mexico cotton graded Extra White or White Strict Middling or better compared with only 23.5 percent for the entire United States, and that 91.8 percent of New Mexico cotton stapled $1\frac{1}{16}$ inches or longer compared with 26.3 percent for the United States crop.

Clipping of cottonseed at the chalazal or rounded ends during ginning, which adds undesirable foreign matter to the ginned lint, was found by the South Carolina station and the Department (B.P.I.) cooperating to be due to outer spongy tissue which constitutes a weak place in the seed coat. Variety and harvesting conditions may also be involved.

Cotton cultivation.—Reasonably close spacing, as, an average of one plant per foot, with rows as narrow as convenient for cultivation, was found by the Mississippi station to give most economical yields. Deep cultivation required more time and horsepower, had no advantage over shallow cultivation, and lowered the acre yield of seed cotton. Laying-by on July 10 resulted in a substantial increase in yield of seed cotton per acre over laying-by July 30, with little difference in weed growth. Early laying-by also eliminates two or three cultivations.

Cotton harvester.—Further improvements refined the Texas station's cotton harvester to a point where 97 percent of the cotton was harvested from varieties at the station and 98.8 percent at Lubbock. Burs, green bolls, green leaves, and trash were removed by an extractor mounted on the same tractor with the harvester. Machine-

stripped cotton graded one grade lower than hand-pulled cotton from varieties at Lubbock.

The value of cotton burs accumulated in this manner was determined by the Oklahoma station. Burs from 22 counties averaged in ash 8.73 percent, nitrogen 1.04, phosphorus 0.1, calcium 0.65, potassium 3.39, and magnesium 0.25 percent on a moisture-free basis. Three tons of burs applied at 3-year intervals either plowed or disked into the soil gave as good returns as 6 tons. Ashes from either quantity produced about one-half the increase in yield as did the burs.

Fertilizers.—Cotton States in the Mississippi Valley have shown increasing interest in the use of fertilizers for cotton. Maximum yield increases per acre in seed cotton, the Mississippi station determined, followed the use of 600 pounds per acre of 8-8-4 and 6-8-4 fertilizer on hill land and 600 pounds of 4-8-8 and 4-8-6 on valley land. Distinct deficiency of nitrogen and distinct to slight deficiencies of potash and of phosphorus, revealed throughout the east side of the Yazoo-Mississippi Delta, showed a need for corrective fertilizers.

Fertilizer balance was shown by the Arkansas station to be highly important for control of cotton wilt and rust or potash hunger. Large amounts of nitrogen and phosphorus in fertilizer, applied either alone or together without potassium or with too little potassium on low-potash soil, gave rise to an unbalanced condition which greatly accentuated rust or potash hunger. This in turn rendered cotton more susceptible to wilt and often resulted in lower yields than on unfertilized plats.

When compared at the Louisiana station, cotton receiving heavy amounts of phosphorus produced higher percentages of seed cotton at first picking, had a higher early blooming rate, and made more seed cotton than cotton unfertilized or receiving no phosphorus. Cotton heavily fertilized with nitrogen was consistently higher in yield, and that given large amounts of potassium was similar in blooming rate, retarded in boll opening, but made much higher yields. A heavy blooming rate, as in the case of phosphorus, did not necessarily mean high yields.

Removal of phosphates from the nutrient medium after cotton fruiting began, the Georgia station reports, hastened maturity of plants receiving nitrates and slightly delayed that of those fed ammonium salts. Boron was found necessary for flower-bud development of cotton and more was needed than for fair vegetative growth. Iron appeared to be the first limiting trace element in midwinter while boron is the first one needed in spring cultures. Superphosphate produced definite increases of seed cotton over colloidal phosphate, which was little better than no phosphate. Working on sandy soils, the Alabama station found gypsum to be a beneficial amendment to cotton fertilizers containing little or no sulfur.

Cotton rotations.—Cotton in rotation with corn and soybeans at the Louisiana station averaged 1,329 pounds of seed cotton per acre as compared with 1,067 pounds from continuous cotton with a winter cover crop, and 957 pounds from continuous cotton alone. Use of winter cover crops evidently is not a good substitute for rotating cotton with corn and legumes. The New Mexico station observed that green manures resulted in lower cotton yields, although cotton after legumes yielded higher than after nonlegumes.

CORN

Hybrid corn.—The development and rapid adoption of hybrid corn has been described as likely to become one of the most important changes in production technique relating to a farm crop in modern times. Expansion of the enterprise has been accompanied by additional research and testing by the stations, often cooperating in organized programs with the Department (B.P.I.), extension services, farmer cooperators, and other agencies. In this connection the Corn Improvement Conference, a group of station and Department workers concerned with corn, meeting in conjunction with the American Society of Agronomy, discusses annually the merits of commercial hybrids, foundation single crosses, foundation and exchanged inbred lines, and station policies on certification and release of lines. The Ohio University and station have cooperated with the Department (B.P.I.) in conducting a hybrid-corn school for instruction in production technique and also in business and merchandising practices. The hybrid-corn industry has grown to such extent that its economic aspects have been considered. The Minnesota station observes that unless new outlets develop it seems improbable that the market can absorb the increased supply of corn which the present acreage can produce when hybrid seed is used, except at materially lower prices. The effect, therefore, depends to an important degree on the extent to which acreage is maintained or curtailed.

More than 5,000,000 acres, as estimated by the Illinois station, were planted to hybrid corn in Illinois in 1938, a remarkable shift from open-pollinated corn. The 5 best hybrids on its 10 test fields surpassed the 5 best open-pollinated varieties by an average of 15.5 bushels per acre and by 13.2 in percentage of erect plants, excelled in most fields in yield of sound corn, and on all fields in erect plants. Certain hybrids were definitely superior to adapted open-pollinated corns in several northern and central sections. Many hybrids were above average in resistance to 2 species of corn rootworms, the only insects causing noteworthy damage on the 1938 fields. The need for fertile soil in order to take full advantage of the high productiveness of good hybrids was shown again. A current objective in the station's program is the development of white hybrids, with kernel types preferred by dry-corn millers, and productive and desirable for the farmer.

Hybrid corn averaged 16.9 percent more in yield than open-pollinated varieties in the 1938 Iowa corn-yield test, cooperative among the Iowa station, Department (B.P.I.), and other agencies, and made the greatest relative increases in districts suffering most from drought. Variations among hybrids again emphasized the fact that many commercial hybrids can be regarded as mediocre to poor. The station cautioned against planting hybrids that may not mature.

Other States in the Corn Belt and elsewhere were experimenting extensively with hybrid corn. The Colorado, Kansas, Michigan, and Missouri stations published circulars on methods of producing hybrids and precautions in their use. Hybrids recommended by the Missouri station from its performance tests include Missouri No. 8 and No. 47 for culture throughout the State and No. 47 and Iowa 13 for northern Missouri. Hybrids of proved value certified for Michigan from cooperative tests include Michigan Hybrids Nos. 561 and 1218

and Minnesota Hybrid No. 402, and also for southern Michigan, Wisconsin Hybrids Nos. 606 and 645.

The Ohio station also carried on an extensive corn-improvement program in cooperation with the Department (B.P.I.). In shelling comparisons between hybrids and standard corn varieties grown comparably it was shown that hybrids differ in this respect and may shell from 1 to 4 percent below high-shelling corn, as Woodburn, or to approach early Clarage. However, in test weights per bushel neither group excelled in general.

In the West the Colorado station made comparisons of hybrids in order to be able to advise farmers as to the best available introduced kinds until its own hybrids could be produced commercially. Minhybrids 301 and 403 were suggested for northern Colorado and certain commercial Corn Belt strains for the Arkansas Valley.

Testing the best material obtainable, the North Carolina station found that several hybrids outyielded and others equaled the best local variety in the western North Carolina highlands. In the Coastal Plain, hybrids from a distance, with a few exceptions, lacked adaptation and were soft, starchy, and light in weight.

The Utah station, after extensive tests in cooperation with the Department (B.P.I.), recommended U. S. Hybrid 52 (Ohio Hybrid C72) for sections with an average growing season, Reid Yellow Dent for those with a long growing season, and Will Allen, Canadian flint, or certain early strains of Minnesota 13 for sections with short seasons. The Massachusetts station also published recommendations based on its experiments on varieties and hybrids and on production practices.

Mexican June corn, found highest yielding in the irrigated valleys of southern New Mexico, was preferred to sorghums for silage production. Under dry-farming conditions, however, the New Mexico station finds the sorghums the more dependable for grain.

White Florident, a new white-corn variety developed by the Florida station from Whatley Prolific and Cuban Yellow Dent, has yielded rather high and offers much resistance to weevil. Seed enough to plant 2,000 acres was distributed in 1939.

Plant color.—Formation of carotenoid pigments in the leaf tissue and in corn endosperm appeared to be independent, according to Minnesota station studies, probably due to independent factors or processes. However, the percentages of chlorophyll and carotenoid pigments in corn leaf tissue were associated. Variations in chlorophyll concentration in corn leaves had no important effect on yield.

Cultural practice.—Ridge culture for corn, the Louisiana station established, required less effort in seedbed preparation and cultivation and returned better yields than level culture. Furrow planting also had several advantages over level planting.

Seed corn.—Timely and proper drying of seed corn with heated air under forced draft, the Nebraska station reports, may remove freezing-injury hazard; facilitate early harvest, storage, and processing; and avoid injury to seed viability or field performance. Reduction to from 12 to 13 percent in moisture content at a temperature range of from 105° to 110° F. was recommended except that temperature be held as low as 105° when the initial moisture content approaches 50 percent. For safe processing and storage a moisture content of less than 14 percent is permissible. The period needed to

dry ear corn to a safe moisture content has varied with the initial percentage and the drying temperature. The Iowa station observed that the corncob dried much faster than either the whole ear or the kernels. Seed corn dried by the Illinois station at 80° to 110° and humidities up to 60 percent yielded more than seed dried at a room temperature of 70° to 80°. Seed dried at 120° to 140° yielded about the same as room-dried seed if any two of the following conditions prevailed when drying: Corn relatively dry, humidity of drying air low, or the drying period short.

Fertilizers.—Foliar diagnosis is defined by the Pennsylvania station as the composition, with respect to dominant elements, of a leaf from a definite position on the stem at the moment of sampling. When corn plants were grown on land that had been variously fertilized but unfertilized since 1881, a relationship was revealed between the nitrogen percentages in the dried corn leaf and in the fertilizer but none between leaf nitrogen and yield nor between fertilizer nitrogen and yield except when phosphorus and potassium were also used. Relationships existed between the phosphorus percentage in the leaf and fertilizer, between leaf phosphorus and yield, and between fertilizer phosphorus and yield, but none between potassium contents. There were indications of association of low intensities of nutrition with low yields in phosphorus, nitrogen, nitrogen-phosphorus, and no treatments, and of high intensities with high yields in phosphorus-potassium and nitrogen-phosphorus-potassium. In cases of excessive consumption of potash, relatively low yields may be associated with relatively high intensities of nutrition, as in potassium and nitrogen-potassium.

That efficiency of corn fertilizers may depend upon the physical condition of the soil was observed by the New York (Cornell) station. Corn supplied with different phosphorus carriers made high yields on the portions of the plats with loose and friable soil but not on an area long under cultivation and very hard and difficult to handle.

The Puerto Rico University station obtained 3,000 pounds of corn per acre with proper fertilization but only 500 pounds under ordinary conditions and cultural methods. Economical production of corn and alfalfa, it is hoped, may permit a reduction in the amount of imported cattle feed and also in animal-industry products.

Continuous corn and soil fertility.—Harmful effects of prolonged continuous culture of corn are well recognized. For example, under continuous corn, 1917-36, at the Iowa station, the organic-matter content of the soil could not be maintained even with relatively large applications of manure. These effects may often be remedied by the introduction of a legume into the cropping system. On Memphis silt loam which without legumes averaged only 30 bushels of corn per acre, the Tennessee station grew corn continuously after stands of *Lespedeza sericea* 3 or more years old with the hay and seed crops removed annually, and harvested 69 bushels the first year, with a gradual annual decline to 37 bushels per acre in the sixth year.

WHEAT

Improvement.—A number of new wheat varieties developed in cooperation with the Department (B.P.I.) and recently released to

growers, including Nebred, a winter-hardy bunt-resistant winter wheat, by the Nebraska station; Pilot, a stem rust- and leaf rust-resistant spring wheat, and Rival, a rust- and drought-resistant spring wheat, both by the North Dakota station; and Thatcher, a productive, high-quality, stem rust-resistant spring wheat, by the Minnesota station, gave encouraging performances in 1939 and were being grown on rapidly expanding acreages. The Kansas station was cooperating with the Kansas Wheat Improvement Association and other agencies in testing the merits of several improved wheats in different Kansas counties. The objectives were a reduced number of varieties which would meet requirements of growers, processors, and consumers.

Idaed and Lemhi are new spring wheats distributed by the Idaho station as results of cooperative breeding work with the Department (B. P. I.). Idaed, derived from Sunset \times Boadicea and recommended for northern Idaho and for irrigated sections of southwestern Idaho, averages 10 days earlier than Federation and has short stiff straw, awnless white glumes, and hard white kernels. It has been grown as a nurse crop for clover with a light seed crop harvested, and also satisfactorily in mixture with barley and oats. Lemhi, from Federation \times Dicklow, resembles Dicklow in quality and color of flour but ripens about 5 days earlier, has a short stiff straw, and is like Federation in maturity and yield. A new winter variety, developed by the Utah station from Relief \times Redit, is an awned hard red winter wheat, apparently resistant to all known races of covered smut in the United States and equal to standard varieties in yield, quality, and other characters. It promises to replace most of the currently grown hard winter wheats on dry farms of northern Utah and southern Idaho.

Strains of Baart and White Federation wheats, incorporating the resistance of Martin wheat to bunt and of Hope to stem rust, were increased by the California station for distribution to growers in 1939. This wheat-breeding program is noteworthy for the production of disease-resistant strains and also for the perfection of a back-crossing technique whereby disease-resistant strains of existing varieties can be developed without disturbing their agronomic characters or impairing their economic values. The South Dakota station was combining desirable characteristics of the most promising new wheats developed in the Dakotas and Minnesota. Crosses involving Triumpho, an Argentine wheat which showed remarkable behavior at Brookings and Highmore, were made in efforts to surpass the best standard wheats during seasons of drought. Triumpho suffered very little grasshopper injury in 1938 as compared with other wheat varieties grown at Highmore.

By crossing Texas Mediterranean wheat with the rust-resistant Hope, the Texas station, cooperating with the Department (B. P. I.), obtained new strains resistant to leaf and stem rusts and greatly outyielding standard varieties in the Gulf coast region.

Wheat and precipitation.—Examination of yields of winter wheat and of sorghums that might have been obtained through the entire period for which precipitation records are available over part of the southern Great Plains, made by the Department (B. P. I.) and cooperating experiment stations in the region, showed that use of water was related closely to wheat yield. A decrease of 1 inch

in average annual precipitation meant fewer good crops, more failures, and, more important, a material increase in the number of times consecutive years of failure might be expected. Precipitation alone was a good basis for estimating sorghum yields. Complete failures were much less frequent than with wheat, but with decreasing average precipitation there was an increasing number of years when sorghum would have made only forage. Yields of sorghum were higher and failures much less frequent on sandy loam soils than on soils of finer texture. The merits of summer fallow and of livestock production as respective ways to minimize wheat failures and their effects were shown.

Analytical study of relations between annual precipitation and spring wheat yields, from data secured over long periods in experiments by the Department (B.P.I.) cooperating with six State experiment stations, brought out that within the limits of precipitation in the Great Plains, the annual precipitation for the year ending July 30 is a close determinant of the yield of spring wheat. Methods such as continuous cropping to small grains that left the soil exhausted of available water when the crop year began increased the dependence of the crop on precipitation during the crop year, whereas the crop depended less on precipitation during the crop year when practices such as summer fallow that stored water in the soil before the crop year began were used.

Wheat under irrigation.—Yield is not the only consideration in the choice of wheats for a region. At the Montana station, Reliance, Comet, Thatcher, and Supreme hard red spring wheats proved superior to Marquis in yield, about equal to or slightly earlier in maturity, and usually about equal in resistance to bunt, yet it was debatable whether they should be recommended instead of Marquis. Thatcher had several good qualities which might recommend it especially where rust influences wheat production. Onas white spring wheat, outyielding Federation by 6.8 bushels and Marquis by 17 bushels per acre, would be indicated if wheat were grown for feed. However, limited demands for white wheat for milling would make the profitable replacement of Marquis or other hard red spring wheat depend on differences in income per acre. Too early an irrigation for wheat, Colorado station experiments demonstrated, may reduce yields about 10 percent because the water carries the available nitrogen below the feeding area of the roots.

Cold resistance.—Two hardening stages of winter wheat were recognized in studies by the Department (B.P.I.) and the Nebraska station. During November and early December, high daily temperature maxima in conjunction with high radiation appeared most conducive to hardening and high temperatures with low radiation or high radiation with low temperatures seemed least effective. Rather dry conditions also appeared to favor hardening. Maximum hardening at this period appeared to result from a radiation-temperature balance reacting with day-length and drought influences to given maximum accumulation of organic reserves. Subsequent exposure to sustained low temperatures resulted in further progressive increases in hardness for about 3 weeks. Reduction in hardness under the influence of reduced light intensity was also reported.

In tests by the Minnesota station on spring and winter wheat plants, freezing resulted in descending order leaves, spikes, and stems. Stem internodes were most resistant and the neck just below the spike was especially sensitive. In general, all leaves and spikes of wheat in the boot and heading stages were killed at 22° F. whereas stems showed up to 50-percent survival; at 28° stems mostly remained unfrozen, but leaves and spikes were at least one-eighth frozen. Injury after freezing was limited to cell areas actually frozen, but after 3 days tissues depending on frozen tissues for transport of water and food material dried up.

Quality.—Spring applications of nitrogen, especially late in May, and also legume crops earlier in the rotations tended to increase the hardness characteristics, such as percentages of protein and of vitreous kernels, as shown in technological studies by the Indiana station on numerous samples of five wheat varieties. Phosphorus alone or in fertilizer mixtures increased yield and decreased vitreousness, protein content, and the loaf volume, and, like spring-applied nitrogen, had small effect on granulation number. Effects of superphosphate were more marked on limed soil, while larger quantities of rock phosphate were the more effective on unlimed land. Soil never fertilized produced wheat of low yield, shrunken grains, and relatively high protein content. Lime alone increased yield, but the kernels remained small and were high in protein. Complete fertilizers used with lime resulted in higher yields and grain with lower protein content and vitreousness and higher kernel weight and test weight. The protein content of milled fractions and, in general, loaf volumes, were related to protein content of wheat. A new technique worked out by the station, involving a new device, the granulometer, enables one to test as little as 1 gm. of wheat meal for fineness or granulation, an important component of quality.

Appraising the 1938 crop of hard red spring wheat, the North Dakota station found that the test weight, flour yield, and loaf color were higher while wheat and flour protein and loaf volume were lower than in 1937. Larger differences in the same quality factors, noted in test weight, flour yield, protein, and loaf volume A in 1937 than in 1938, appeared due to the extensive rust epidemic of 1937, which in large areas affected life processes of the plant and consequently kernel constituents. The importance of test weight to flour yield, of wheat protein to flour protein, and of flour protein to loaf volume was manifest. Thatcher wheat showed higher flour yield and loaf volume than Reward, Ceres, Marquis, and other varieties tested.

Kanred and Marquis wheat stored at the Colorado station for 9 years and milled by the Department (B.A.E.) in comparison with these varieties grown recently by the station proved good in milling and baking tests. Maintenance of germination and milling quality in prolonged storage was possible because of the low relative humidities in the region. Storage under controlled higher humidities, e. g., close to 100 percent, destroyed germination in from 2 to 4 weeks.

OATS

Improved varieties.—Productive and disease-resistant oats, developed in cooperation with the Department (B.P.I.) and released to farmers, included Fulton, early and resistant to oat smut, by the

Kansas station, and Boone, an early, leaf rust- and leaf- and stem smut-resistant oats, and Marion and Hancock, both possessing high resistance to lodging, all three by the Iowa station. Nakota, a new variety of hull-less oats developed by the South Dakota station, was released and distributed in the spring of 1939. Bannock oats, released in 1938 by the Idaho station to farmers in irrigated sections of southern Idaho, has yielded from 90 to 106 bushels per acre, and the crops were smut-free and stood up well under irrigation.

By the introduction of Fulghum oats and development of the Columbia variety, the Missouri station made decided improvement in the oats crop of its State. Combining earliness, efficiency as a nurse crop, and productiveness, either far surpasses any other kind of oats ever grown in Missouri. Columbia currently represents much more than half the total oats crop of Missouri and has gained favor rapidly in adjoining States.

Oats in the rice region.—The Arkansas station found oats desirable in rotations to clean up old rice fields. At the rice substation where hazards from rust are greater than the hazards from winter-killing, red rust-proof varieties, such as strains of Ferguson, Hasting 100-Bushel, and several others, have made best yields. These are not immune or entirely resistant to rust but head out and make considerable development ahead of or in spite of rust attack and produce 40 to 80 percent of a crop, while under like conditions white, yellow, or gray oats return only 5 to 25 percent of a crop. Winter oats at the main station in the period 1920 to 1939, even though the 1928 crop winter-killed, averaged for all varieties 37 percent higher than all spring varieties, and weights per bushel of winter oats were from 5 to 12 pounds more than for spring oats.

BARLEY

Improvement.—Conway, a new smooth-awned barley bred by the New Mexico station, consistently equaled and usually outyielded the best hooded or rough-awned varieties and was expected soon to be in commercial production. Winter, a superior strain of winter barley developed by the Texas station in cooperation with the Department (B.P.I.) and being distributed to Texas farmers, makes much more fall growth and earlier spring growth than Tennessee Winter and has averaged over 50 bushels per acre during 5 years compared with 35 bushels for standard barleys. Velvon, a new smooth-awned barley with relatively stiff straw, white kernels, and resistance to covered smut, brought forward by the Utah station and the Department (B.P.I.) in cooperation, made remarkable response to later planting and equaled or surpassed other good varieties in yield. From 3,500 to 4,000 acres of Velvon were grown in Utah during 1938. A practical result of barley genetic research at the Colorado station is the production of Lico barley, distributed in 1939. Lico, a smooth-awned barley, has surpassed Trebi in yield, stiffness of straw, and quality.

Barley growing.—Practices found productive in experiments with barley by the Kansas station, the Department (B.P.I.), and others included a firm seedbed with plenty of moisture in the upper subsoil; such rotations as sorghum, barley, and wheat, or sorghum, barley,

fallow, and wheat; from 5 to 7 pecks per acre sown from March 15 to April 10; and choice of the productive, barbless Flynn or the older Stavropol or Malt, all spring barleys. Among the harvest methods used, combining has been cheapest, harvesting with the swather pick-up has given better quality but cost more, while binding with careful shocking and early threshing produced the highest quality of grain.

In Oregon the barley crop, averaging over 2,000,000 bushels from about 75,000 acres, has remained fairly constant during 35 years. The Oregon station reports that barley is used most widely as a feed grain, but is also prized for hay in the drier sections, grown with legumes for hay or silage where moisture is adequate, and excels as a nurse crop for legumes and as a green manure and cover crop in western Oregon. Of the higher-yielding varieties, Hammchen has produced good malt and a higher percentage of extract than most malting barleys. Oregon barleys have been slightly lower in diastatic activity than malting varieties in the main producing areas.

Malting quality.—Comparisons of five important commercial barleys by the Department (B.P.I.) working with the Wisconsin and other stations (a phase of the cooperative barley breeding and malting research program) disclosed that in malting quality at least, Velvet smooth-awned barley resembles Oderbrucker and Manchuria. Wisconsin Barbless, grown extensively in the north-central area, appeared inferior to these varieties in malting quality. Periodic cutting tests showed that cutting barley before fully mature reduces extract yield.

RICE

Rice growing.—Information on rice culture in the Southern States, gained in cooperative investigations with the Louisiana, Texas, and Arkansas stations and published by the Department, considers cultural and field methods, varieties, irrigation, harvesting, and threshing practices; control of diseases, insects, and weeds; and the milling and utilization of rice. Research in cooperation with the California station has provided similar information.

New varieties.—Consumer preference for long, thin-grained rice that cooks quickly into a flaky dish has increased demands for Rexoro, Nira, and Fortuna, new rice varieties developed and distributed by the Louisiana station and the Department (B.P.I.) cooperating. In 1938 these rices were planted on nearly 185,000 acres, including Rexoro, the preferred rice, on 106,000 acres, Nira 49,000, and Fortuna 29,000 acres, comprising about 20 percent of the entire southern crop compared to about 100,000 acres in 1937. Demand was reflected in the higher price for the milled rice, which often was almost double for the new varieties, and in higher prices to farmers.

FLAX

Movement of seed-flax growing into new areas where high acre yields return substantial profits has been made possible by cooperative station and Department (B.P.I.) research on varieties and cultural methods. Acreage in California has increased in 6 years from a small beginning to about 100,000 acres in 1939. In the Imperial

and South San Joaquin Valleys the highest yields and the best quality as measured by oil content and iodine number were obtained by the California station from early fall plantings, while in the Sacramento Valley good yields often came from late winter planting. In the Imperial Valley excellent yields could be secured by planting in cultivated rows where one or two cultivations were effective in the weed control essential to success. When grown as a winter crop in southeast Texas by the Texas station, 10 to 15 bushels per acre were produced on dry land and 25 to 30 bushels under irrigation compared to 7 bushels, the acre average for the United States. About 10,000 acres were planted there in the fall of 1938.

Practices found desirable for seed-flax culture in eastern Washington, from experiments and experience of the Washington station, include the choice of the Bison variety, planting in early spring from 40 to 45 pounds per acre not deeper than 1 inch on a well-prepared seedbed on weed-free land, and if ripe and dry, harvesting with a combine, or if not dry or containing green weeds, cutting with the binder or swather and drying before threshing. Alfalfa and sweet-clover have made good stands when sown with flax as a nurse crop. At current local prices flax returned a lower acre value than winter wheat, oats, and barley but higher than spring wheat and peas.

Improvement.—The stations in the principal seed-flax-producing areas were also conducting extensive improvement programs, usually in cooperation with the Department (B.P.I.). Examples of such endeavors are the progenies from a cross involving Buda 80, Rio, and B. Golden flaxes, made at the North Dakota station, that averaged high in plant height, seed weight, oil content, and iodine numbers, were immune from all local rust forms, and showed no killing from wilt on the soil in which grown.

POTATOES

Improvement.—New potato varieties coming forward during the year mainly as products of the national improvement program of State stations cooperating with the Department (B.P.I.) included Sebago, productive, high in quality, and resistant to late blight and particularly to mild mosaic, and Earlane, early and highly resistant to mild mosaic and a good keeper, both by the Maine station, for Maine and northern areas; Pontiac, by the Michigan station, a late, productive, drought-resistant potato free from hollow heart and giving encouraging results from Florida and Louisiana to North Dakota; Sequoia, by the North Carolina station, high yielding and resistant to virus diseases, late blight, leafhoppers, and flea beetles; and Red Warba, by the Minnesota station, early and productive for home or market.

Seed and planting practices.—Observing that northern-grown (5-month dormancy) seed of four varieties surpassed Louisiana fall-grown (3-month) seed and Louisiana spring-grown (9-month), usually in order and with differences in sprouting and plant production, the Louisiana station concluded that for best results the dormant period should be long enough for seed pieces to sprout rapidly when planted, with vigorous resultant plants, but not so long as to produce multiple sprouting and stunted early-maturing plants.

Treatment of still dormant Heavyweight (Smooth Rural) seed potatoes with a 30-percent wax emulsion, the New York (Cornell)

station reported, resulted in stimulation of sprout growth, earlier emergence of plants, and a corresponding increase in yield, probably due to the conservation of moisture accompanied by sprout-growth stimulation. The beneficial effects resembled those produced by green sprouting. Russet Burbank potatoes, treated at the Idaho station with 4-percent water solutions of potassium thiocyanate and thiourea, gave marked increases in sprout production, and when planted in the field gave rise to increased number of stems and tubers per hill with reductions in tuber size. The Minnesota station found tetrachloroethylene, 2 cc. per cubic foot, more desirable than other reagents for breaking the rest period of potatoes.

Seed sources.—Comparisons embracing some 12,000 tests in the United States and Canada showed a 46-bushel per acre superiority for certified over noncertified seed. The Alabama station found from more than 1,000 comparisons during 4 years that disease may not be the main cause of wide differences in productiveness and consequently in value of different potato-seed lots. Diseases might account for about 25 percent of the differences between lots of certified seed, yet there may be physiological differences in seed lots due to variation in growing conditions, maturity, storage, and transportation that are more important in determining potato yields in the South.

That seed potatoes produced in the mountainous section of north Georgia will grow well in Florida was shown in cooperative experiments by the Georgia and Florida stations. Efforts were being made to so improve seed stock as to develop an important and profitable industry for the mountainous section of Georgia and also effect savings for Florida growers. Colorado certified Irish Cobbler seed, the New Mexico station reported, outyielded seed grown in Bluewater, N. Mex. Yields from level culture of potatoes have been heavier than from ridge culture.

Potatoes have produced good crops in the Matanuska Valley, and a good market exists for all being grown, the Alaska station reports. However, unless care in production is exercised, the tubers are often of inferior quality. Acre yields of potatoes when well fertilized were, for Arctic Seedling 312 bushels, White Bliss 308, Early Ohio 240, and White Gold 175 bushels.

Irrigation.—Potatoes grown by the Department (B.P.I.) cooperating with the Colorado station were irrigated (beginning early) throughout the growing season whenever needed to maintain continuous growth and typical foliage color in comparison with late irrigation, first applied 2 or 3 weeks later or when plants were dark green and growth checked. Early irrigations caused much faster growth and development of stolons, resulted in an early set and more rapid tuber development, and produced more tubers weighing 85 gm. or above, but had little effect on number of stolons or tubers per hill.

Fertilizers.—Foliar diagnosis (see p. 13) of Rural Russet potato plants on soil variously fertilized, at the Pennsylvania station, revealed that addition of each dominant nutrient element to the soil increased its percentage in the leaves. Its utilization, however, was influenced by the presence of other nutrients in the fertilizer as was illustrated by potassium accumulation in leaves from soil receiving potash

fertilizer with insufficient nitrogen or phosphorus. Nitrogen content of leaves was not related to plant development, but low content and low use of phosphorus accompanied poor development. Equilibrium between nitrogen and phosphorus throughout the season and a maintained rapid use of potassium at a high level were associated with good development.

Commercial fertilizers have not been very promising for increasing potato yields in Colorado, according to the Colorado station. Phosphate was most consistent in increasing yields and the starch and dry-matter contents. The appearance, maturity, handling qualities, and russetting in the Russet Burbank potato were also most favorably affected by phosphate. Potash was conducive to better tuber shape and when applied at a light rate with a heavy quantity of phosphate produced the best tubers.

Yields secured in different localities by the West Virginia station demonstrated the need by potatoes of a complete fertilizer, and that lack of available potassium invariably results in low production. Row application of 1,400 pounds per acre of a 5-10-10 mixture returned the largest yields of No. 1 tubers. When used in combination with this fertilization, boron, magnesium, and iodine slightly lowered yields in the order cited.

Fertilizer of 4-16-8 or similar formulas gave yield increases consistently among the highest produced on different soil types and under varied weather conditions in experiments by the Michigan station, cooperating with the Department (B.P.I. and B.A.Engin.). However, formulas containing more potassium in relation to phosphorus, as in a 3-12-12 mixture, often gave as good or better yields, especially on the sandier soils. Rates from 500 to 600 pounds per acre were indicated, although under irrigation heavier rates were used efficiently and fertilizer could safely be placed closer to the seed piece. Large yield increases followed the use of manure or commercial fertilizer, as 4-16-8, particularly where both were used.

Fertilizer placed in a band at each side of the row usually produced the most rapid emergence of sprouts, most vigorous plant growth, and highest yields of primes and total yields in continued placement studies by six State stations, the Department (B.P.I. and B.A.Engin.), and other agencies. From a practical viewpoint, the preferable placement was in a band 2 inches to each side of and on the lower level of the seed piece. Single- and double-strength fertilizers furnishing like amounts of plant food gave similar results in actual potato yields and order of yields for various placements.

When complete fertilizer for potatoes was compared with separate ingredients on Sassafra sandy loam by the Virginia Truck station and the Department (B.P.I. and B.A.Engin.), the materials supplying nitrogen when applied in the row retarded emergence and decreased yields to the greatest extent, while potassium had minor retarding effects. Since it exerts no appreciable injury at normal rates, placement of superphosphate in contact with the seed piece seemed desirable. Because nitrogen carriers when in contact with the seed piece are most injurious, they might be placed on each side in combination with potassium carriers to avoid injury and to promote fertilizer efficiency.

Beneficial effects of soybean and sorghum green manures on potato yields on two soil types were reported by the Virginia Truck station. Fresh organic matter was about three times as effective as residual organic matter in increasing yield. The green manures added plant nutrients to the soil in about the equivalent of 1 ton per acre of 7-2-5 fertilizer.

SWEETPOTATOES AND OTHER ROOT CROPS

Features of research with sweetpotatoes included production of starch from both surplus and specially grown crops; breeding for higher starch content, table quality, and disease resistance; and improvement of production practices. In publications on growing the crop, the Mississippi station featured plant production and fertilization, while the Kansas station stressed disease control.

Improvement.—As a result of research on breeding technique, continued by the Louisiana station with trellised, girdled plants grown by special methods, it is recommended that the flower be closed with a paper clip in the afternoon before opening, emasculated between 5 and 6 a. m. the next day, reclipped, crossed between 8 and 10 a. m., and the clip again replaced to avoid insects. Seed capsules are bagged when two-thirds grown until ripening, when the seed can be stored or planted. Immediate germination is assured by treating seed for 20 minutes with concentrated sulfuric acid that is washed off before planting.

More plants were produced by large seed, i. e., roots 2 to 3.5 inches thick, than by small seed, 1 to 1.5 inches thick, in the Mississippi station experiments at Laurel, but the plants were no larger and small seed produced more plants per bushel earlier and for the entire season. The station determined that carefully handled seed stock sprout earlier and are superior otherwise to roots given ordinary care.

Fertilizers.—Working together with sweetpotatoes on Orangeburg sandy loam and Norfolk sandy loam, the South Carolina station and the Department (B.P.I.) obtained only small gains in yield of sweetpotatoes with increasing amounts of potassium in mixtures also containing 3 percent of nitrogen and 8 percent of phosphoric acid. Marked effects of potassium upon shape evidently would be found only where potassium deficiency was relatively serious. The shape of the Porto Rico variety was influenced by potassium slightly more than Nancy Hall or Big Stem Jersey. Increasing the nitrogen content of fertilizer from 2 to 8 percent (4-8-4) apparently did not affect the proportions of the various grades or the shape of the roots of Triumph sweetpotatoes grown by the Mississippi station in different soils at Laurel, Miss. Reviewing recent fertilizer experiments with sweetpotatoes, the North Carolina station showed plant-food needs to differ extensively with locality.

Storage.—Sweetpotatoes should be placed in a curing house within a few hours after digging and kept for 10 days at from 80° to 85° F. and a relative humidity of 90 percent, according to experience of the Mississippi station. The temperature should then be reduced gradually and maintained at about 55° throughout storage. At the Oklahoma station roots of Nancy Hall sweetpotatoes shrank least in storage and kept satisfactorily after curing at a temperature as low

as 70°. Porto Rico roots kept best following curing at 92°, with slightly greater storage losses after curing at 80°. The greatest storage losses were found in roots of the Maryland Golden, for which about 90° should be used in curing.

Root crops for forage.—Practical information published on growing rutabagas, mangels, turnips, and carrots for feed was based on research by the Michigan station and Upper Peninsula substation, and considered the choice of crop, production costs, cultural methods and field practices, storage, and preparation for feed, and indicated the merits of Jerusalem-artichoke as a silage and root crop.

TOBACCO

Improvement.—Findings in tests of varieties of cigar-wrapper tobacco resistant to black shank, by the Florida station, substantiated the opinions of packers and manufacturers, and the sales indicated that cigars wrapped with leaf of such tobaccos (especially Rg and 301) were acceptable to the trade.

A strain of white burley tobacco containing about 0.02 percent of nicotine, selected from hybrids by the Kentucky station, was evidence that low-nicotine burley could be produced. Another selection of apparently excellent burley tobacco when cured ranged from 0.29 to 0.89 percent in nicotine, and its hybrids with poor burleys very low in nicotine gave plants excelling in type and quality, with from 0.01 to 1.2 percent of nicotine.

Fertilizers.—The need for a physiological approach to the problem of fertilizer for tobacco, particularly on light sandy and sandy loam soils, was shown by the North Carolina and Maryland stations cooperating with the Department (B.P.I.) from tests that resulted in the discovery of magnesium deficiency in these soils, accompanied by characteristic crop symptoms. Soil deficiency in calcium, magnesium, and sulfur as much as in nitrogen, phosphorus, and potassium was demonstrated in specific cases by marked depression in yield of tobacco, definite symptoms, and abnormally low content of the deficient element. Soils chosen with respect to such deficiency criteria and with variation in the supply of only a single essential element provided information on absorption by the plant in relation to increased supply of this element. This plan of "field sand cultures" has given reliable results in research on effects of the nitrogen supply on growth and development phenomena, metabolism, and other internal relations, and on chemical and physical properties of cured leaf. Characteristic effects of deficient supplies of nitrogen, phosphorus, potash, magnesium, calcium, boron, sulfur, manganese, and iron on field-grown tobacco plants were reported from similar cooperative nutritional studies during 20 years in producing areas.

Excessive rains in the summer of 1938 caused heavy losses of plant nutrients in the Connecticut Valley. In that growing season the Connecticut (State) station determined that normally fertilized sandy loam in tobacco lost, through leaching, nitrogen approximately 100 to 150, potash 50 to 75, lime 140 to 160, and magnesia 30 to 40 pounds per acre. Leaching losses were generally in inverse proportion to the weight of crop. Corrective measures were advised for calcium deficiency attributed to the same cause. Soil under calcium-starved tobacco was negative for replaceable calcium but did not

show unusual low acidity. The superiority of soybean meal over cottonseed meal in a higher yield and grade index of leaf and higher crop value, shown earlier, was verified in 1938, although the tobacco was greatly depressed in yield and quality.

Formulas, acre rates, and plant-food sources were again recommended by five experiment stations in the South and the Department (B.P.I.), based on their cooperative research, for fertilizers for flue-cured, sun-cured, and shipping tobacco of the 1940 crop and for plant beds on tobacco soils.

Quality.—Havana Seed tobacco and probably Broadleaf also should remain in the field at least 3 weeks after topping and often up to 4 weeks for optimum yield and grading, according to Connecticut (State) station results. Leaf-by-leaf analysis of Havana Seed tobacco revealed a gradual and regular increase in the percentage of total nitrogen from the bottom to the top of the plant until the uppermost leaves contained about three times as much as the lowest. Since this increase is accompanied by corresponding increase in nicotine, the upper, darker leaves make a "stronger" smoke and must be fermented more thoroughly before satisfactory for cigars. Variations in contents of other essential elements were also determined.

Using curing chambers designed to give complete control of heat, humidity, circulation of air, and other factors involved in curing tobacco, the Kentucky station determined that humidity rather than temperature may be the most important factor in developing the bright leaf that brings the top price. The best quality of burley tobacco was obtained where humidity ranged from 65 to 70 percent. Expert graders could not distinguish consistently between tobacco cured at 65° and at 90° F., and usually preferred leaf cured at a constant humidity of 68 percent to that cured at 77 percent for 2 weeks and then at 68 percent.

Burley tobacco varies widely in color and quality from year to year and from one production area to another. The Kentucky station observed that the quality of tobacco for sale also varied considerably throughout a given marketing season. In most years average quality improved for the first 2 or 3 weeks and then declined for the rest of the season. About half of the seasonal fluctuations were due to variations in quality and half to changes in prices, grade for grade. High grades varied relatively less in price during the season than lower grades. Quality was an important factor and other factors were secondary. Seasonal fluctuations in price and in quality were much greater in burley than in eastern fire-cured tobacco.

SUGAR CROPS

Sugar beets.—Domestic production of sugar beet seed, now essential to American producers because of war conditions, especially in the seed-growing areas of Europe, was begun and developed by the New Mexico station cooperating with the Department (B.P.I.) concurrently with breeding of curly top-resistant varieties. As a result of station activities, the industry has extended to other beet-growing States in the western United States, even to valleys in Oregon where, according to the Oregon station, a new enterprise has been established on a commercial basis. In current work the New Mexico

station has obtained highest yields of sugar beet seed after alfalfa, in particular, and cotton when the land was fallowed during the season before the early September planting. Small grain and Sudan grass were not desirable as preceding crops. In the cooperative tests of sugar beet strains, U. S. 33 and U. S. 15 had the highest sucrose contents, while U. S. 12 was most resistant to curly top disease.

More regular spacing, better stands, and an increase of 20 percent in the number of single beets in the row have been made possible by a new planter developed cooperatively by the Department (B.A.Engin.) and the Colorado and California stations. The planter differs little from the standard beet planter but selects single seeds by a series of small cups on the face of a disk furrow opener. Beets so planted can be thinned with a long-handled hoe, thereby cutting the time for blocking and thinning to one-half that needed with stoop labor.

Since the sugar in the beet falls as the soil nitrates rise, the Colorado station observed that a suitable nitrogen-phosphate balance must be maintained in the soil for reasonably high yields without adverse effects on sugar content. Where nitrates could not be controlled suitably, some improvement has been secured by fertilization with phosphates.

Sugar beet roots for seed production were kept by the Colorado station and the Department (B.P.I.) in open crates without coating or packing material during five winter storage periods with negligible loss from rotting, by maintaining the root-cellar temperature a few degrees above freezing, humidity near saturation, and thorough air circulation. The method was found to be convenient and efficient.

Sugarcane.—New sugarcane varieties bred by the Florida station are much earlier maturing, disease resistant, and high yielding on the organic soils of the Everglades. Their use has permitted the beginning of milling operations 6 weeks earlier than formerly and with a higher yield for the season, i. e., about 46 tons of cane per acre, averaging 196 pounds of refined sugar per ton. Improved large-barreled varieties, also bred by the station, are displacing inferior canes in commercial plantings. One improved variety for sirup production in north Florida made a 3-year average of 662 gallons of 39° Baumé sirup per acre. Two strains of sugarcane developed at the Puerto Rico University station have been superior sugar yielders. Pr-900, which has yielded 7 tons of sugar per acre, will be distributed if it equals or surpasses well-known commercial canes in comparative tests.

The Hawaii station found that for germination of sugarcane buds soil temperatures should not be below 72° F., and that stands are best in soils exposed to direct sunlight with temperatures between 85° and 95°. Germination is also influenced by length of seed piece, position of buds, and age of planting material.

The Hawaiian Sugar Planters station found that reverted and raw rock phosphates equaled calcium superphosphate in availability to sugarcane on the acid, high phosphate-fixing soil used, all three resulting in yields 10 times those made by controls. Superphosphate and reverted phosphate returned larger yields on limed than on unlimed soil. Marked differences in available phosphate supplies did not cause differences in percentages of phosphorus in millable cane, although the tops reflected the soil's phosphate supply.

SORGHUM

Improvement.—Early-maturing sorghum varieties developed by the Texas station cooperating with the Department (B.P.I.) have made possible the production of two crops in a single year in south Texas and an almost unlimited quantity of forage. By combining the grain and drying it in commercial dehydration plants, the early spring crop can be placed on the market when supplies of carry-over grain are low and prices are relatively high. These agencies continue to serve growers by developing improved strains and varieties that are more desirable than older sorghums because of greater yields, increased resistance to diseases and insects, or greater nutritive value.

A strain of Double Dwarf milo resistant to *Pythium* root rot (*P. arrhenomanes*) developed by the California station has saved an important industry in the delta section of California and probably also in other sections of the State. Resistant strains developed in the Great Plains had been found poorly adapted to California conditions. Sorghum strains low in hydrocyanic acid, released by the South Dakota station—for example, low-acid Dakota Amber (No. 39-30-3)—ripen uniformly, and when harvested in the matured stage and well cured in shocks promise to eliminate considerable forage poisoning.

Hydrocyanic acid (HCN) content.—Extended study by the South Dakota station has shown that environmental conditions promoting normal and regular growth in sorghum evidently lead to minimum HCN content, while conditions retarding normal development result in corresponding increase in HCN in subsequent growth. The HCN content varied with variety; was controlled by heritable factors, low HCN being partly dominant over high HCN; averaged eight times as high in leaves as in stems; varied with time of day and locality; was lower in response to fertilizers except nitrogen; rose after green manure; was lower in irrigated than on dry land, dropping with increased soil moisture; was gradually lost in curing, particularly in the sun and with exposure to air; was liberated faster and more completely than normal by freezing; and was not related to total sugar content in the strains studied.

Growth curves.—Hegari and milo, field-grown at the Arizona station cooperating with the Department (B.P.I.), produced about 10 to 15 percent of the final dry weight of stalks and heads in the first half of the growing period. A much slower increase in growth in early developmental stages and a faster increase at later stages were noted than expected from the symmetrical sigmoid growth curve typical of many plants. Size of seed planted was related closely to the dry weight per stalk in early development stages of varieties of sorghum, corn, and proso, representing a wide range of seed sizes. Seedling size was a logarithmic function of the "active mass" in the seed.

SOYBEANS

Soybean growing for seed, hay, pasture, and soil improvement, and lately as a vegetable, continued to expand rapidly in the Corn Belt and other northern States, in the South, and in other regions of the United States, attaining a total of 10,006,000 acres in 1939.

This acreage produced 87,409,000 bushels of beans and 6,263,000 tons of hay and included 1,357,000 acres grazed or plowed under. The total production in 1939 in the six principal commercial producing States was estimated at about 82,000,000 bushels of beans. Trends in this direction have presented many new problems for the station and Department workers on varieties, inoculation, fertilization, cultivation, effect of day length, and utilization.

Improvement.—Soybeans have advanced rapidly to major importance in many areas in the South, especially in the Delta section of Mississippi where the Mississippi station, cooperating with the Department (B.P.I.), has brought forward the productive Mamloxi, Delsta, Mamredo, Delnoshat, and Tanloxi soybeans as products of an extensive breeding and testing program. The station's experiments also have pointed to appropriate cultural, fertility, and inoculation practices. In like manner, improved varieties and practices have been derived from research of the Illinois, Indiana, Iowa, Kansas, Ohio, Louisiana, North Carolina, and other stations.

Limitations of soybeans.—Effects of soybeans on soil productivity have been studied by several stations. The Illinois station finds that soybeans, to fit most usefully into Illinois cropping systems, must be handled to contribute to soil conservation and not to cause soil depletion. Best control of erosion where soybeans are grown on rolling land has been accomplished by drilling solid and following with a winter cover of drilled small grain, both crops on the contour. Where soybeans are drilled solid up and down the slope, erosion losses usually have been reduced about half.

Advantages of the solid drill (8 inches) method over wider rows (28 inches) were established by the New York (Cornell) station for early varieties of soybeans grown for grain. Yields increased as the arrangement of plants on a given area approached a uniform distribution, i. e., until the distance between rows equaled the space between plants in the row. Optimum rates and spacings evidently should be determined for both the different producing areas in the United States and for soybean varieties. A variety has an optimum number of plants per unit area for maximum net increase, being six plants per square foot for the Cayuga soybean.

Edible soybeans.—The adaptation of the vegetable type of soybeans to production throughout Illinois and the favorable reception of the green-shell beans as a home-garden vegetable, were demonstrated in cooperative experiments by the Illinois station and the Department (B.P.I.). Varieties well adapted to central Illinois also have thrived in other Midwestern States, but for northern Illinois, Iowa, and localities farther north early kinds have been most reliable. Cannery tests showed the feasibility of processing an acceptable product from certain varieties. Most of the 18 varieties studied were found suitable for use as dry beans as well as green-shell beans. For a succession of green soybeans in Illinois, one variety should be selected from each of the very early, early, midseason, and late groups. Methods of growing, harvesting, shelling, and cooking vegetable soybeans have been published by the station.

ALFALFA

Grown throughout the United States on nearly 13,494,000 acres in 1939, with a total production estimated at 27,035,000 tons, alfalfa,

a leading forage legume, continued to offer numerous problems for station research.

New varieties.—Bacterial wilt has been a major factor, together with recent droughts, for appalling reduction in acreages of alfalfa over large areas, particularly in Kansas and Nebraska. The Department and State stations have recognized the seriousness of this disease, and, observing the resistance of Turkistan, Ladak, and Kaw alfalfas in infested areas, have secured by exploration in Europe and Asia, especially in Turkistan, resistant varieties for breeding work. Recent accomplishments in these activities include new wilt-resistant strains, developed by the Nebraska station and the Department (B.P.I.), from hybrids made with resistant Turkistan stock. They equal or surpass Hardistan alfalfa in wilt resistance and out-yield Hardistan and equal Grimm in seed and forage production. Several have much greater leaf spot resistance than commercial Turkistan and all recover faster than Ladak after cutting. Orestan alfalfa, a new Turkistan strain highly resistant to bacterial wilt developed by the Oregon station, equals commercial varieties in yield and quality. Substantial progress was also made by the Kansas, Wisconsin, Rhode Island, and other stations in genetic and breeding research with alfalfa.

Prolonged experiments under mountain State conditions led the Colorado station to recommend Meeker Baltic for short rotations, with Grimm and Hardistan second, and Hardistan for long rotations where a stand of alfalfa is to be kept longer than 3 years. Ladak alfalfa endured winter at the Alaska station in good condition, while Grimm and common alfalfas were completely winter-killed. Yellow Blossom alfalfa proved very successful, but its tendency to creep along the ground makes harvesting difficult.

Fertilizers.—Alfalfa responded in higher yield to phosphate treatment at the New Mexico station but not at the New Jersey station where the soil was found to have a reservoir of phosphorus in the 42-inch layer amounting to from 10,000 to 12,500 pounds of phosphoric acid per acre. In New Jersey the hay tended toward a higher percentage of phosphorus with increase in application. Phosphorus content of alfalfa hay at the West Virginia station was also markedly influenced by fertilizers, particularly on soils low in available phosphorus. The first cutting was lower in phosphorus content than the second or third. Boron applied at the rate of 30 pounds per acre by the Oregon station controlled yellow top of alfalfa, while at the New Mexico station results from treatments with copper, manganese, zinc, iron, and boron were of no significance.

Growing the crop.—Based on prolonged experiments and experience, the Colorado and Oregon stations outlined cultural, irrigation, and harvesting practices, as well as varieties of alfalfa for Colorado and western Oregon. The standard rate for seeding alfalfa in Ohio has averaged from 10 to 12 pounds per acre, yet planting experiments by the Ohio station and the Department (B.P.I.) indicated that 7 pounds is enough under the best conditions. If as much as 15 pounds per acre does not give a satisfactory stand, some condition other than seeding rate needs correction.

That alfalfa can be produced successfully in irrigated sections of Puerto Rico was shown by experiments at Isabela by the Puerto Rico University station. The index of digestibility of home-grown alfalfa

was high. The crop was expected to play an important role in the utilization of valuable lands which would be removed from sugarcane culture because of low sugar quotas.

Cutting.—The best date to cut alfalfa, the Ohio station found, depends on the use of the crop. Since yields increase until about June 15 without serious loss of protein, cutting from June 1 to 5 is advised for the greatest feeding value per acre without injury to stand where only two cuttings are made in most of the State. Hay cut in late May usually contains 20 percent or more of protein and is in demand for poultry, yet cutting at this time reduces storage of root reserves and weakens the stand. Mixtures including alfalfa should be cut for the alfalfa for best quality.

The New York (Cornell) station observed that the best method under the climatic conditions at Ithaca is to first cut alfalfa about June 20 and again at a growth stage comparable with the first cutting. Very early cutting has tended to suppress weed growth, whereas a very late second cutting has given satisfactory yields but seriously diminished the stand. Clipping alfalfa weekly at 1- and 2-inch heights was found by the Wisconsin station to reduce markedly new top and root growth and root reserves compared with that uncut or cut at 6 inches. The Michigan station found that weekly cuttings lowered food reserves, subsequent top growth, and the water requirements. Early cutting in drought periods would tend to maintain greater soil-moisture reserve for later growth than deferred cutting.

Curing and storage.—Alfalfa hay cured most rapidly in the swath at the Iowa station, but the color was best when it was cured in small cocks made at once after cutting or when cocked after one-fourth swath-cured. Hay of good quality and color was secured with a fairly short curing period by windrowing after it was one-fourth swath-cured. Tedding hay in the swath or turning windrows with a rake did more harm than good in favorable curing weather, and several other operations tested either lowered quality or delayed curing. Alfalfa double-windrowed from 2 to 3 hours after cutting, the Mississippi station determined, produced hay with the lowest percentage of moisture at the end of the day, more leaves, greener color, and of better grade.

Hay put in the mow when containing less than 30 percent of moisture, as shown in Iowa station experiments, may be considered safe from excessive heating, and hay with less than 25 percent of moisture may retain color and quality. Detailed report was made on the causes and adverse effects of heating. Hay baled from the field with 23 percent of moisture was stored without detrimental heating.

Seed production.—That the effects of temperature on alfalfa seed production are more important than of humidity was observed by the Kansas station. Maximum set of seed pods was obtained at from 70° to 95° F., while above 100° seed-pod production decreased rapidly. Variation in relative humidity from 5 to 70 percent had slight influence on the number of pods. Neither factor influenced the number of seeds per pod within the temperature range for good seed set.

CLOVERS AND OTHER LEGUMES

Clovers.—Studies on white clover by the Connecticut (Storrs) station revealed the superiority of strains native to pastures of England, New Zealand, and the United States in maintaining stands in

grass-clover seedings, the lesser prevalence of clover in bluegrasses or bents than with grasses having more open stands, the retarding effects of nitrogen fertilizers due chiefly to increased competition of grass, and definite responses to phosphates, lime, and other minerals. Close cutting greatly decreased Ladino and Kent clovers in Kentucky bluegrass-clover seedings.

White and Ladino clovers, found by the Florida station to be the highest yielders among winter pasture clovers, furnished earlier grazing, became established sooner than other legumes if planted on moist soil types, and tended to be perennials and to seed prolifically. Either could be planted alone or as the major part of a clover mixture. Ladino clover under test at the Pennsylvania station led other domestic and foreign white clovers by a wide margin in yield and in ability to survive under pasture conditions. The Oregon station has published practical suggestions for growing and handling Ladino clover for hay and pasture in western Oregon, based on cooperative experiments with the Department (B.P.I.).

Certain native strains of red clover produced in the Central or Eastern States have given good results in New Jersey station tests. Kentucky Selection 101 from the Kentucky station has been carried forward and about 100 acres were to be harvested for seed in 1939. In a new crop rotation developed and found desirable by the Missouri station, red clover is spring-sworn in barley fertilized especially with phosphates, the barley harvested in late May or early June, and the clover used as pasture, hay, or as an unharvested soil-improvement crop. The second-year growth is so manipulated that self-seeding will occur.

Wild European or Lappa clover (*Trifolium lappaceum*), according to the Alabama station, promises to become valuable on the heavy clay soils of the Black Belt of Alabama and other Southern States. This cold-resistant creeping annual reaches a height of 18 inches on good soil, yields much hay, is excellent for pasture, and reseeds when cut for hay or pastured. Seed germinate in the fall and the plants reach a height of 4 or 5 inches in February, make rapid spring growth, and die in June.

Sweetclover.—The value of sweetclover for rejuvenating eroded land was proved by the Ohio station. Yields on virgin Canfield silt loam before and after removal of 10 inches of topsoil were, respectively, corn 75 and 14 bushels and oats 66 and 12 bushels. On the eroded land, oats after corn treated with manure, lime, and fertilizer returned 14 bushels, while oats following sweetclover plowed under made 59.5 bushels, almost as much as on the untreated virgin soil.

From extensive studies by the Washington station, Spanish (Madrid White), Madrid (Madrid Yellow), and Willamette sweetclovers are recommended, on the basis of yield and leaf percentage, for production of first- or second-year hay and Alpha 1 for cover cropping. Yellow and white sweetclovers did well in the first year at the Alaska station but few plants survived the winter. The seed produced in the first year came up the next spring and provided a fairly good stand.

Lespedeza.—A legume forage related to clovers, lespedeza, is grown for hay, pasture, and seed, and for soil improvement and conservation on increasing acreages, chiefly southward from the Potomac, Ohio, and lower Missouri Valleys into the northern part of the Cotton Belt.

In 1939 lespedeza-hay production in the United States totaled 3,860,000 tons from 3,692,000 acres.

Korean lespedeza grown by the Missouri station on level prairie soil responded to phosphates in increased crop and nitrogen harvest, especially when used with limestone. Used together, these materials also served to mobilize the phosphorus into the crop more effectively for increase (83 percent) in the total crop harvest and in its relative content of protein. Likewise, the Department (B.P.I.) cooperating with the North Carolina station observed that four kinds of lespedeza responded to phosphate and lime on infertile Cecil gravelly loam and that the calcium, crude protein, and phosphorus contents were increased in Kobe and Korean lespedezas. Under low phosphate availability, Kobe and Korean lespedezas endured drought better than the common variety.

One-year rotations of small grain and Korean lespedeza, one of the most fruitful achievements of the Missouri station and an increasingly popular practice in Missouri, have been found economical and adapted to a wide range of soils. More than one-third of the Missouri farmers who in 1938 grew over 2,600,000 acres of lespedeza were growing the crop in such rotations. Acre yields secured from wheat-lespedeza on average land in 1938 were 22.5 bushels of wheat and 133 pounds of gain in beef cattle grazing on volunteer lespedeza after wheat harvest.

Korean lespedeza was found by the Delaware station to have definite possibilities for relieving the July pasture shortage. Several strains isolated by the station were proving superior for the sandy soils of southern Delaware.

Birdsfoot trefoil (*Lotus corniculatus*), found promising by the New York (Cornell) station as a dual-purpose crop, furnished in the summer of 1938 three times as much pasturage during a dry period as wild white clover, and in feeding value its hay approached alfalfa.

Hairy vetch.—Hairy vetch (*Vicia villosa*) produced much more growth at the Alabama station when superphosphates were mixed with soil before adding inoculants than when the fertilizer contacted the soil inoculant. Such ill effects of superphosphate were offset by dolomite. Fertilizer or inoculation, especially in combination, increased the growth of vetch and the content of nitrogen, largely in the tops.

Higher yields of seed cotton, 1,701 pounds per acre, attributed to nitrogen (83 pounds) from hairy vetch, over unfertilized land, 1,036 pounds, were produced by the Mississippi station at about half the cost of the higher yield also resulting from 30 pounds of commercial nitrogen, 1,361 pounds. That the plowing under of a good stand of hairy vetch at 10 inches or more in height should add nitrogen enough for cotton and other crops was shown by Texas station experiments.

Trailing wild bean (*Strophostyles helvola*), a seed-propagated annual common throughout the Mississippi Valley and east to the Atlantic coast and remarkably resistant to heat and drought, was observed by the Iowa station to thrive on clay soils and on eroded banks and sides of gullies, although usually found on sandy soil. Its value as a green manure and nitrogen replenisher and on eroded waste areas was evident.

Lupinus angustifolius grown from inoculated seed by the Florida station was well nodulated and produced from 17.5 to 20 tons of green

weight per acre, and 30 acres at the North Florida substation yielded over 1,400 pounds per acre of viable, re-cleaned seed, easily harvested with a combine. Derived from a small lot supplied by the Department (B.P.I.), the legume is being tested extensively as a winter cover crop for the South.

Sesbania was shown by the New Mexico station to be outstanding as a green manure for soil improvement, especially on land not yet in cultivation.

Cowpeas.—Strains of Blackeye cowpeas resistant to cowpea wilt, nematodes, and charcoal rot, developed by the California station, yielded in 1938 from 20 to 42 sacks per acre on infested land which in 1937 had produced only 5 to 7 sacks of common Blackeye peas. Outstanding strains were under test for further selection and ultimate distribution of an early and a medium-late maturing variety.

Field beans.—*Michelite*, a new white navy bean released by the Michigan station and derived from Early Prolific × Robust, combines resistance to mosaic and to field infection of bacterial blight or wilt with the productivity of Robust and the uniformity and glossy white seed coat of Early Prolific.

Application of fertilizer in a single band from 1.5 to 1.75 inches below the bean seed and in bands 1.5 inches out from the seed were most promising among band-placement methods tested cooperatively by the Michigan station and the Department (B.A.Engin.). Fertilizer broadcasted was not profitable as to increase in yield even when plowed under. The 0-16-8 fertilizer gave better results than 0-16-0 or 4-16-8 mixtures but more than 300 pounds per acre was not economical. Sweetclover green manure plowed under for beans also gave good results on two soils.

Peanuts.—Many promising hybrid peanut strains studied by the Georgia station surpassed Spanish and Carolina Runner in yield of nuts, several producing almost twice as much as Spanish. Five hybrids produced more than 2 tons of cut hay per acre and nut yields ranged from 825 to 2,056 pounds. Increased yields following application of sulfur dust appeared to be due partly to disease control and partly to action of sulfur in the soil.

Number of peanut plants per hill had little effect on yield in North Carolina station tests, and different spacings did not affect greatly the percentages of hand-picks or large- and medium-shelled nuts or total shelling percentages in the Virginia Bunch or Jumbo Runner varieties. Two plants to the foot was the best spacing. The station also observed differences in response to fertilizers and amendments on several soil types in the peanut belt in eastern North Carolina.

Peanut-hull bran, a byproduct of the industry, was reported by the Florida station to be effective and economical for rooting cuttings when mixed in equal volume with sharp white sand. It is reasonably free from weed seeds, toxic substances, and damping-off organisms, and in the vicinity of the Gulf coast costs about one-fourth as much as imported peat moss.

GRASSES AND HAY

Grasses and the problems of their production, management, and use have received much attention in recent years from the experiment stations and the Department. These and other agencies were

cooperating during the year on a regional basis in breeding new strains, in studies on the influence of environmental factors on growth, seed production, and adaptation, and in experiments on palatability and grazing values. A number of stations published practical information gained from such activities, including circulars on grasses and legumes for pasture and hay by the North Dakota station, on common native grasses by the Nebraska station, and grasses on dry farms by the Utah station. The Oklahoma station issued an instructive manual on Oklahoma grasses.

Timothy.—Seeding tests by the Ohio station cooperating with the Department (B.P.I.) indicated 3 or 4 pounds per acre of timothy seed to be a satisfactory rate with winter grain in the fall and 10 pounds when spring-sown with oats as a companion crop. At Wooster, sodium nitrate with superphosphate and potassium increased acre yields of hay and protein. At North Ridgeville, superphosphate and potassium increased hay yields chiefly through larger growth of volunteer clover. For highest quantity and quality of hay, timothy evidently should be cut in early bloom. Summer applications of sodium nitrate made before harvest increased yields of hay and also of protein more in grass cut early than in that cut late.

The times of heading, blooming, and maturing of timothy, according to other research in the same cooperation, is determined largely by temperature and length of day. Late selections required longer days than early ones for production of stems and inflorescences. For the earliest selections the blooming season progressed from south to north, while for the latest selections blooming occurred first at a midlatitude and then progressed both northward as the temperatures became suitable for growth and southward as the hours of daily illumination gradually increased.

Completing a 3-year study on fertilizing timothy to improve its protein value, the New Jersey station recommends application of 100 to 150 pounds of a soluble nitrogen carrier and then harvesting the crop 10 to 20 days later. The practice is of special value on areas where grassland farming is important and the growing of legumes presents serious difficulties.

Bluegrass.—Kentucky bluegrass, in studies by the Department (B.P.I.) cooperating with the Missouri station, made good above-ground growth at an air temperature of 40° F. and continued to grow even at 90°, but the roots grew best at a soil temperature of 60° and stopped growing at 80°, which explains summer "dormancy" of bluegrass. Canada bluegrass reacted much as did Kentucky bluegrass, except that best temperatures for root and herbage growth were about 10° lower than for Kentucky bluegrass. Bermuda grass began normal growth with soil and air temperatures about 60° and both roots and herbage grew well at 100°, but the grass was injured severely at 40°. Orchard grass made best above-ground growth at an air temperature of 70°, grew slowly at 80°, and stopped at 100°. Its roots grew best when the air and soil were 60° to 70° but continued to grow at 80° in the lower depths—8 to 16 inches. This explains why orchard grass will grow farther south than bluegrass.

Most nitrogen carriers applied to Kentucky bluegrass and Rhode Island bentgrass by the Connecticut (Storrs) station resulted in significant increases in total nitrogen. April applications of a single carrier were followed by a greater recovery than when applied in other months. The New York (Cornell) station has determined the relationship between the incidence of Kentucky bluegrass and Canadian bluegrass in New York pastures and different chemical soil measurements.

Sudan grass.—Rapid progress was reported by the Texas station in breeding for new strains of Sudan grass with sweet, juicy, and pithy stems, nonshattering seed habits, resistance to foliage disease, and marked with distinctive glume colors. A promising strain practically uninjured by a severe infestation of *Helminthosporium turcicum* is homozygous for prolific side branching and tillering habits and produces much forage. Dairy cows grazing on 150 progeny rows of Sudan grass distinctly preferred the juicy-stalked and sweet-stalked selections.

The ability of Sudan grass to produce hydrocyanic acid is inherited, according to the Colorado station, which obtained high, low, and intermediate lines by selfing. Indications were that the amount of nitrates in the soil at certain seasons has a physiological influence on production of the poison. Some lines seemed much more responsive to environmental changes than others.

Meadows and hay.—In the Ohio station's experiments with summer seedlings of meadows the chief hazards have been dry soil, heat, weeds, volunteer grain, and delay in sowing. Favorable practices included preparation of land for summer seeding as soon as possible after small-grain harvest, plowing weedy land instead of disking, and seeding, without a nurse crop, in July or early August when soil moisture was favorable. Stands and growth have been improved by a light mulch of straw or manure applied just after seeding.

Alfalfa-timothy mixtures were found by the Iowa station to be well adapted for hay purposes, especially on less fertile upland soils. Over a period of 3 years such mixture returned from 30 to 35 percent more hay than alfalfa alone. Yields and feeding value of timothy hay have been increased by growing in this mixture. Timothy made up from 25 to 50 percent of the first cutting while the second cutting was almost entirely alfalfa. The station advises seeding 10 to 15 pounds per acre of alfalfa and not over 5 pounds of timothy with the same cultural practices as for alfalfa grown alone. Smooth brome grass did better at the Michigan station in mixture with alfalfa than when grown alone.

Responses of grass hay to different plant foods and to complete fertilizers under several soil conditions led the New Hampshire station to suggest that since returns from top dressing per dollar invested are small, farmers should consider the history of their fields and determine fertilizer needs by a rapid soil test. A 1-1-1 ratio of plant nutrients was more satisfactory than a 1-2-2 ratio for grass hay, assuming annual applications. In cuttings made from June 10 to July 30, more protein and a higher protein forage were obtained from the earlier harvests. Colonial bent and redtop, the Rhode Island station determined, may require less potassium and phosphorus for good growth than does timothy, yet all three grasses need high nitrogen fertilization.

In experiments by the Michigan station the reaction of quackgrass to variations in height of cutting and nitrogen treatments indicated that fertilization should result in increased top growth usable for hay or pasture and that later control measures on quackgrass so treated should prove less difficult. In the Upper Peninsula quackgrass meadows treated about May 1 to 7 with 200 pounds of ammonium sulfate per acre broadcast and cut early, June 17 to 25, returned a much greater yield of protein (9.13 versus 6 percent) and about 0.5 ton per acre more hay of better quality than unfertilized meadows cut late, July 8 to 15, the current practice. When cut weekly at 1-, 3-, and 6-inch heights at this station, cooperating with the Department (B.P.I.), grasses were injured in the increasing order Kentucky bluegrass, quackgrass, smooth brome grass, and timothy and orchard grass about equal. Total yields of top growth and underground parts usually were highest from plants allowed to go unclipped and decreased as cutting was more severe.

Seeking a substitute for native redtop, which does not endure mowing or grazing, the Alaska station noted that western ryegrass, Fairway crested wheatgrass, Kentucky bluegrass, meadow fescue, and western wheatgrass came through the winter in excellent condition, while brome grass, timothy, and reed canary grass were not very successful. However, timothy planted with Russian red clover survived the winter in excellent condition and would yield about 2.5 tons per acre.

Distinct differences in susceptibility of seedling grasses to attacks of grasshoppers were observed in 1938 by the North Dakota and Washington stations. In Washington, wide variations in comparative susceptibility to damage were noted among selections within each species. Indications were that relative resistance to attack might be a measure of ease of establishment of certain species in areas where grasshoppers were numerous enough to damage but not destroy the plants.

Lawn and sport field grasses.—The economic and social importance of turf areas either as lawns, parks, or recreation fields has incidentally directed attention to problems of turf production. The New Jersey station estimates that in its State there are about 500,000 lawns of various sizes and a large acreage of turf in parks and other public areas. Raritan Velvet bentgrass, its new strain released for commercial use, has proved superior for lawns in shaded areas and on infertile soils and also suitable for the finely cut turf desired on putting greens and tennis courts. The station also published directions on growing grass under shade trees.

Suggestions on lawn grasses and their management were published by the Rhode Island station from recent experiments. Rhode Island Colonial bent and also Piper and Kernwood velvet bent, adapted grasses tolerating acid soil, low fertility, and close clipping, form good lawns with proper attention. Kentucky bluegrass is good with Rhode Island Colonial bent on sports areas. Chewing and red fescues survive on soils too dry for bents or bluegrass, tolerate acid soil or dense shade, and withstand closer clipping than bluegrass. Domestic or Italian ryegrass has value as a nurse grass in mixtures for steep slopes, athletic fields, and where a quick growth is wanted to shade and protect other types and suppress weeds. Fertilizer high in nitrogen, such as the 10-6-4, 8-6-6, and 8-6-4 formulas, is indi-

cated for general use on lawns. Lead arsenate controlled crabgrass and chickweed and earthworms and webworms in turf.

Buffalo grass, the Kansas station reported, makes a satisfactory lawn under many conditions of high temperatures and light rainfall, being well adapted for lawns in the central and southern Great Plains. Four-inch cubes of sod were found efficient in spreading the grass, and when spaced 1 foot apart in rows 1 foot apart have covered the intervening space in 1 year under dry-land conditions, or 2 feet apart each way with watering or other more favorable conditions.

Seed and germination.—Bahia grass seed germinated faster in studies by the Department (B.P.I.) and Georgia Coastal Plain station when variously scarified by friction or treated with sulfuric acid. Crude sulfuric acid for 40 to 60 minutes was about as effective as 10 minutes in technical sulfuric acid, much cheaper, and less dangerous to seed from overtreatment. Seed of other southern grasses responded with higher or faster germination to treatment with sulfuric acid, hydrochloric acid, or sodium hydroxide.

Noting that developed seeds of Indian ricegrass sink in water while undeveloped seeds float, the Utah station devised a method of separation. Treatment with concentrated sulfuric acid for periods depending upon the size of seed raised germination over 50 percent. The Iowa station developed and published improved methods for determining purity and viability of bluegrass seed.

Planting depth, the Minnesota station observed, was the major factor determining total emergence of seedlings of individual common forage crops. About 0.5 inch deep was satisfactory for the five grasses and five legumes studied, although surface planting produced good stands with conditions ideal for emergence. Variations were also noted among species on the several soil types involved. Legumes reached maximum emergence about 5 days before the grasses, indicating that conditions favoring emergence for grasses must continue longer after planting.

PASTURES AND RANGES

The Nation-wide interest in pasture improvement and management continued to provide numerous opportunities for the forage specialists of the experiment stations, many of whom cooperated with the Department in seeking new and improved pasture plants, fertilizer methods, and management practices.

An example of pasture research in the Eastern States is the Rhode Island station study on practices on dairy farms and cooperative improvement work, resulting in practical suggestions on fertilizers, liming, seeds mixtures, and pasture management. The station found that increased use of tillable land for pastures was warranted by the returns. Farmers tended more and more to use supplementary and temporary crops for pasture to obtain even grazing throughout the season and usually found it profitable to fertilize and lime pastures. Kentucky bluegrass and white clover became dominant in well-managed permanent pastures. Complete fertilizer and lime applied to permanent pastures resulted in greatly increased yields of grass and brought about decided savings in the cost of milk produced.

Far to the southwest, on the Gulf coast prairie, the Texas station proved that Dallis, Bermuda, carpet, and Angleton grasses, Califor-

nia bur-clover, White Dutch clover, and common lespedeza were good for permanent pastures when supplemented by proper drainage and mowing to control weeds. Fertilizers, however, were not profitable. With seeding and mowing a good sod was established in only 2 years and the pasture contained more kinds of grasses in a more uniform mixture than in a pasture mowed only for 4 years. Improved permanent pasture could carry more stock and produce more total gain per steer yearly because of the more nutritious herbage and longer productive grazing period than unimproved native pasture.

In management experiments by the Louisiana station pastures in southern Louisiana were made more productive by application of nitrogen and phosphorus and by grazing with dairy cows. Variations in composition of forage could be traced to advance of season, fertilizer treatment, and time of cutting. Under the conditions of limited pasture area the moderate and careful use of nitrogen and deficient elements was found to be an economical practice.

Bermuda grass responded strikingly to nitrogen in Georgia station pasture research, although such treatments decreased the lespedeza content of the clippings. Lespedeza responded to lime but was little affected by phosphates. Crimson clover was more productive and stimulated Bermuda grass more than did other clovers. The station finds that a good pasture system should include both the crimson clover-Bermuda and the Bermuda-lespedeza types of pasture for maximum grazing at different times.

The most profitable returns on pastures in its State, the West Virginia station determined, may in general result from the use of superphosphate and lime, particularly on unproductive soils with a high potential yielding capacity, i. e., acid soils low in available phosphorus but not droughty, badly eroded, or on very steep slopes. Fertilizer and lime increased the percentages of desirable plants, particularly of Kentucky bluegrass and white clover, and materially lowered the percentages of weeds, poor native grasses, and bare ground. Supplemental nitrogen may give profitable returns if the extra pasture can be used efficiently but need not be applied where a good stand of white clover is present.

Acre returns gained by the Ohio station from fertilized, limed, and rotated pasture, which comprised nitrogen-fertilized bluegrass for early grazing, bluegrass-white clover for main-season grazing, and alfalfa-timothy for midsummer grazing, employing both dairy cows and beef steers, equaled the value of cash crops of corn, small grain, and hay on similar land and were double the returns from unimproved pasture.

Applications of about 140 pounds of 20-percent superphosphate per acre per year to permanent pastures outside the bluegrass region, as shown by the Kentucky station cooperating with the Tennessee Valley Authority, will increase herbage production about 20 percent and protein production per acre about 25 percent. Liming increased protein but not herbage. Each dollar spent for limestone and phosphate produced a return of \$5 measured in terms of value of protein. Fertilizer seemed best applied to pastures between fall and spring, and broadcasting always equaled or surpassed subsurface treatments.

That having another grazing crop to take up where one leaves off, such as Korean lespedeza following Kentucky bluegrass when the

latter becomes dormant in midsummer, means more and better beef-cattle gains was demonstrated in cooperative experiments by the Missouri station and the Department (B.A.I. and B.P.I.).

Yield curves of pasture grasses, as determined by the Illinois station, paralleled precipitation curves rather closely but were the reverse of temperature curves, i. e., when temperature rose grass yields tended to decrease. Alfalfa has been rather uniformly productive throughout the grazing season. Kentucky bluegrass may have some serious defects but it has excelled in general adaptation, utility, and persistence. Bromegrass has outyielded other grasses, appeared to be high in palatability, and has persisted remarkably well. Considering growth and consumption, orchard grass seemed to rank along with Kentucky bluegrass.

In grazing experiments with five grass-legume combinations in three localities, the Minnesota station secured 2,208 pounds of total digestible nutrients per acre from grazing when plants were 4 inches high, 2,600 pounds at 8 inches, and 3,055 pounds at 12 inches. Grazing at the 12-inch height increased by 11 percent the digestible protein recovered over that available at 4 inches.

Mixtures containing bromegrass, slender wheatgrass, crested wheatgrass, and sweetclover, the North Dakota station reports, produced good stands the first year and promised high-yielding pastures. Inclusion of timothy and reed canary grass in upland pasture mixtures for eastern North Dakota seemed a doubtful practice. While spring seedings have given best results in general, soil blowing makes spring seeding hazardous on bare ground in western North Dakota, and fall seeding in stubble or other cover may be more successful.

Trees (set out in 1926) were observed by the Tennessee station to have increased the carrying capacity of bluegrass-white clover pasture in middle Tennessee. Pasture days for 1937 and 1938 averaged 43 percent more for the locust and 39 percent more for the walnut areas than was obtained on an unshaded area.

Range.—While subject to more severe environmental and grazing conditions, the western range has many problems in common with the natural and tame pastures of eastern regions.

The restoration of depleted range and return of abandoned cropland to range have been considered by several stations cooperating with the Department and other agencies. The Colorado station estimates that it may require from 60 to 80 years for abandoned fields to return naturally to the better native grasses, as blue grama, and that the grazing value would remain very low for a long time. Artificial revegetation is hampered by adverse climate and scarcity of adapted range-grass seed. Western wheatgrass-sod cubes spaced 4 feet apart covered bare ground in 2 years at this station, suggesting that this way of transplanting grasses that revegetate rapidly either by surface runners or underground rootstocks may be an ultimate solution in many areas where seeding is impracticable. Buffalo grass spread more slowly but formed a more complete cover. Further evidence of the value of crested wheatgrass in returning abandoned grassland to permanent range was obtained by the Montana station. By the end of 1938, 57,000 acres had been planted to the grass in the Government range-improvement program in north Montana alone in addition to that sown by individuals.

Management and utilization practices for black grama grass, considered essential to southwestern ranges because of its wide occurrence, forage value, and use in soil conservation, were outlined by the Department (F.S.) cooperating with the Arizona station. Studying range revegetation, the New Mexico station noted that the upright stems of black grama grass remain green for from 4 to 6 inches of the bases throughout winter and contain carotene enough for the vitamin A requirements of range cattle.

On good range in southern Arizona, the diet of jack rabbits was determined by the Arizona station to consist of herbs 21 percent, grasses 78, and of trees and shrubs about 1 percent, thereby competing almost directly with range cattle. A few coarse grasses fairly palatable to cattle may be relatively free from rabbit damage on a range with good plant cover and be valuable for reseeding exhausted ranges.

The most desirable foothill range, the California station observed, contains a mixture of grasses and woody species. Crude protein content in all groups, including grasses, broad-leaved herbs, and shrubs and trees, has been highest in early growth stages and lowest at leaf maturity. The grasses have been well-balanced in inorganic constituents, but in seasons unfavorable to growth the annual herbaceous species may be low in phosphorus. When the chaparral cover, largely chamise, buckbrush, and manzanita, which tends to encroach on certain foothill range lands, was burned with a view to improving the forage and keeping the lands open, the little-browsed chamise and manzanita, which sprout vigorously after burning, produced as much as 1½ tons of air-dry material per acre, yet some palatable herbage has come in and has persisted for about 2 years after burning. Burning has had little effect on the chemical composition of the forage but on some of the steeper slopes was followed by severe erosion.

Analyses by the Utah station of 16 species of forage plants growing on winter range in Juab County revealed significant correlations between ash and calcium, magnesium, and sulfur; calcium and magnesium, and sulfur; phosphorus and crude protein, and crude fat; and sulfur and crude protein. Significant negative correlations were found between ash and phosphorus, and crude fat; calcium and phosphorus, and nitrogen-free extract; and between crude fiber and phosphorus, sulfur, and crude protein.

Underground food reserves of little bluestem and big bluestem grasses decreased markedly in percentages of invert sugar and hydrolyzable material under severe clipping at the Nebraska University and station. Drought during 1934 and 1935 had similar but lesser effects on stored nutrients of unclipped plants. Nitrogen was almost constant under all conditions.

A close relation between the annual growth of native range grasses, seasonal precipitation, and seasonal gains in livestock was observed by the Colorado station. Western wheatgrass and green needlegrass, the ranker growers, were found to depend more upon spring precipitation for growth and to provide the main forage in spring, while blue grama and buffalo grass, short grasses higher in temperature requirement, make maximum foliage growth and constituted the principal forage in July and August. Samples collected in the late August dry period showed that blue grama had one-third more protein than western wheatgrass.

The big bluestem type of vegetation was found by the North Dakota station to produce more forage per unit area than any other major vegetation type in western North Dakota. In 1938 it out-yielded the uplands type (grama-needlegrass-sedge) which in turn produced more than the Badlands slope type (western wheatgrass-grama-sedge). Forage yields of the different types were related closely to supply of available soil moisture during the growing season.

Many valuable perennial grasses decreased markedly in abundance as a result of the great drought of 1934-37, according to the University of Nebraska. Little bluestem was depleted greatly and disappeared from some prairies, and bluegrass, big bluestem, and Indian grass became much sparser on uplands. Most forbs gradually died out to as little as one-third of their former abundance and many annual grasses and weeds decreased. On the other hand, the perennial *Aster multiflorus*, with rhizomes, spread widely into drought-bared areas and ruined many prairies for hay production, and many forbs with fleshy storage organs became very abundant. Western wheatgrass, sparse when the drought began, spread widely and occupied large proportions of many former bluestem prairies, and many native grasses, including short grasses, also became far more abundant and important. During the drought period changes occurred also in grassland and range vegetation in the western North Dakota Badlands. The North Dakota station observed serious reductions in abundance of blue grama grass, western wheatgrass, and needle-and-thread, with definite and in some cases striking recoveries in the last two more favorable years. Annual and perennial forbs also were reduced in number during drought years but made large gains later.

The most important grasses in the Hawaiian range have been described by the Hawaii station, which also indicated their origin, occurrence, and value on the range.

WEED CONTROL

Recent changes in the agriculture of the United States have accentuated the weed problem, already of serious proportions. At the same time the experiment stations, bureaus of the Department, and other official and local agencies have taken more effective action to control these menaces to crop production. The more practical experimentation aimed at immediate control by chemicals, cultivation, rotation, and other farm practices is being based more and more on the fundamental research of botanists, especially plant physiologists, and of chemists. Their efforts have been reinforced and supplemented by legislation, better seed control, and well-organized State-wide weed-control programs, as in Kansas, Nebraska, Utah, Idaho, and California.

Bindweed.—Field bindweed or wild morning-glory continued to be a major pest in certain Corn Belt and Western States. The relation of bindweed root reserves to control measures has been examined by the Iowa station. Rapid and nearly complete disappearance of polysaccharides after chlorate treatments without corresponding rise in sugars suggested the destructive oxidation of the reserves within treated roots, probably by stimulation of respiratory processes. Slow

depletion of reserves from the deeper roots under fallow treatment indicated that such attempts to eradicate deep-rooted old stands should follow preliminary treatments made to reduce reserves of the deeper roots. Otherwise clean fallow for three or more seasons may be needed to eradicate the plants. The usual type of smother cropping seemed of less value for preliminary treatments than anticipated. The sharp overwinter drop in reserves and rapid recovery following new spring growth suggested that fallowing treatments should begin promptly with the first growth to take advantage of the low reserve level.

Intensive cultivation of land heavily infested with bindweed, the Iowa station observed, may kill the main root to about 18 inches deep at the end of the second year. Such land, after 28 cultivations at first emergence of aerial shoots during the growing season 1936-38, was free of bindweed in 1939, but fewer cultivations were not so satisfactory. Corn on a heavily infested area kept free of bindweed by weekly hoeing produced twice as much as on land cultivated 3 times. Winter wheat and winter rye grew effectively on infested land without material decrease in grain yield. Sudan grass, cane, millet, and soybeans drilled solid also reduced the number of bindweeds.

The Idaho and Minnesota stations cooperating with the Department (B.P.I.) found cultivation to be effective in bindweed control where intervals of 2 to 3 weeks elapsed between tillage operations, and the Colorado station showed a 3-inch depth of cultivation to be as good as 6 inches. A short fallow to about July 1 followed by such summer smother crops as Sudan grass, sorghums, millet, or soybeans was effective in Minnesota. Normal wheat yields were obtained in Idaho on heavily infested fields after the land was summer fallowed for 1 year and plowed 8 inches deep in early fall before seeding the wheat. Fall application of dry sodium chlorate has been found an effective chemical control in Idaho. The Colorado station also reported that efficiencies of commercial chlorate spray materials were in proportion to their chlorate contents and that weed burners have been too costly for weed control.

Crabgrass.—Crabgrass was controlled at the Ohio station by the use of 20 to 25 pounds of lead arsenate per 1,000 square feet, either in mixture with soil, as dust, or as spray, preferably applied from October to April. After-effects in reduction of later growth of Kentucky bluegrass were overcome by liberal use of fertilizers high in nitrogen and by limestone. Calcium and manganese arsenates and arsenic pentoxide also were effective on crabgrass but injured desirable grasses.

Nutgrass.—Treatment of infested soil with chloropicrin, from 400 to 750 pounds per acre, and covering with mulch or kraft paper or wet soil gave the Texas station practical control of nutgrass. Cost per 100 square feet approximated \$1 for chloropicrin and a few cents for gas-proof paper for cover. This method is deemed practicable for small gardens, flower beds, and small infestations, but may cost too much for large-scale field application in which case the tillage method of the Alabama station, i. e., plowing or disking at intervals of 3 weeks or less during two successive growing seasons, is advised. Since chloropicrin is deadly to plant life, it should not be applied near living shrubs or trees, in gardens, or in flower beds.

Pricklypear.—Poisoning and grubbing, which includes piling, were the most economical methods of eradicating pricklypear (*Opuntia* spp.) in studies of the Texas station on the Edwards Plateau. Costs of grubbing ranged from 25 cents to \$3 an acre and of poisoning from 25 cents for light infestations to \$2.50 or \$3 for heavily infested areas. The most effective poison consists of 3 pounds of arsenic pentoxide per gallon of water to which is added 1 pint of commercial sulfuric acid, the solution being best sprayed in summer on both sides of the slabs and terminal joints in a fine mist with a special atomizer using from 110 to 120 pounds of air pressure. A metal alloy termed 18-8-S stainless steel was found to resist the action of the poison enough to permit of its use as sprayer or atomizer tanks.

Quackgrass.—Nitrogenous fertilizers applied to quackgrass, together with early and close cutting or close pasturing, the Michigan station demonstrated, promote quick exhaustion of carbohydrate reserves in the roots and rootstocks by production of new top growth, thus starving them and destroying their ability to sprout. The leaves and above-ground stems produced by plants so fertilized are rich in proteins and high in feeding value.

Whitetop.—Ranch land of the Nevada station, near Elko, heavily infested with whitetop or hoary cress, was plowed, cultivated for 1 year, and then seeded heavily with pasture grasses, clovers, and alfalfa. Under moisture conditions favorable to both, the pasture plants became established after several years and practically crowded out the weed.

Range shrubs.—Because of its spring forage value, control of velvet mesquite on grassland ranges rather than eradication is suggested by the Arizona station. The expense and labor of eradicating undesirable plants seemed justified only where palatable range grasses and forage plants will replace them. Application of sodium arsenite to the sapwood by frilling the base of stump or tree with downward ax strokes and its rapid absorption in lethal quantities by the root system was cheaper and more certain than other methods tested and about equally effective in any month. It also proved successful for killing unwanted trees in yards and along fence rows and ditches. Kerosene sprayed at the rate of 1 pint to a 5-inch trunk to a height of 2 feet, with the nozzle held close to saturate bark, preferably in June, also was effective.

Burroweed and snakeweed or broomweed, unpalatable perennial shrubs more or less poisonous to livestock and likewise spreading into the better grassland ranges, were unusually resistant to sprays. Torching of scattered plants or careful broadcast burning of patches was the most effective control.

Herbicides.—Textural grade of the soil is the important factor in arsenic and borax toxicity, while nitrate concentration controls chlorate absorption by plants. These observations in California station experiments, cooperating with the Department (B.P.I.), were finding broad substantiation in the field. Since in most soils fertility as denoted by production of crops and roadside plants is determined by nitrate concentration, plant growth evidently may predict response to chlorate applications. In highly fertile soils costly experimentation with chlorates may be avoided and a program involving carbon bisulfide or cultural or cropping practices substituted. The station also found that effectiveness of carbon bisulfide against per-

ennial weeds is related to soil texture, temperature, compaction, and particularly soil moisture. A relatively dry subsoil with a shallow layer of moist or compacted soil on top to hold in the vapor provides ideal conditions. Textural differences seemed great enough to warrant revision of current recommendations, i. e., reducing dosages on light soils and possibly increasing them on heavy soils.

The acid-arsenical spray for deep-rooted perennial weeds proved practical in control of Russian knapweed by the California station in the San Joaquin Valley, and it might be used on some species of whitetop. Fractions high in aromatic compounds obtained in refining petroleum now diverted into fuel oils, it was shown, might displace Diesel oil now used in roadside spraying, effecting considerable saving. The station reported that in 1939 about 6,000 acres were treated with Sinox (sodium dinitro cresylate) to kill broad-leaved weeds in cereals and flax, and also in onions and corn. About one-third of the area was covered by airplane, a method found very effective under certain conditions. The Ohio station also controlled buckhorn in lawns by one or two applications of a 2-percent solution of Sinox.

Treatment of compost soil for top dressing turf with chloropicrin (tear gas), the Rhode Island station shows, has killed weed seeds, and more effectively with the higher soil and air temperatures. Fumigation of soil by injection of liquid chloropicrin resulted in increased yields of mangels, rutabagas, and millet, and a number of truck crops, and freedom from certain diseases.

Sodium chlorate was quite effective against Johnson grass at the New Mexico station but not so good against nutgrass. Dry applications of sodium chlorate and Atlacide were about two-thirds as effective as sprays. The Department (B.P.I.), cooperating with the Minnesota station, has developed a machine, costing between \$30 and \$40, for applying sodium chlorate in dry form with much less time, labor, and expense than the old sprayer type of machine. It consists of a V-shaped hopper mounted cartlike on two rubber-tired wheels.

HORTICULTURE AND FORESTRY

CONTENTS

	Page		Page
Fruits and nuts.....	44	Vegetables—Continued.....	
Varietal improvement.....	44	Physiological studies.....	62
Pollination requirements.....	45	Storage and handling.....	63
Genetic studies.....	46	Ornamentals.....	63
Propagation.....	46	Propagation.....	63
Improved cultural practices.....	48	Cultural methods.....	63
Better use of fertilizers.....	52	Storage practices.....	65
Fruit thinning.....	53	Forestry.....	65
Physiological studies.....	54	Reproduction.....	65
Storage and handling.....	56	Species trials.....	66
Vegetables.....	57	Silvicultural requirements.....	66
Development of varieties.....	57		
Genetic studies.....	58		
Better cultural methods.....	59		

Year by year, slowly by the very nature of the work, painstaking researches by trained horticulturists and foresters in their respective fields are building up a storehouse of knowledge that leads to more efficient and more economical practices. Sometimes it may be the

disproving of existing concepts based largely on empirical trials, sometimes the development of new varieties particularly adapted to certain requirements, as, for example, preservation by freezing, and again it may be the development of better methods of conducting various operations in the field and greenhouse.

The goal is no longer increased production as a whole but rather the development of techniques that lead to more profitable production of higher-quality materials. With insect and disease problems in an everchanging state of flux, new problems in control are constantly developing. Because of changing conditions, both biologic and economic, perfection in horticultural and silvicultural practice obviously cannot ever be fully attained but it is certain to be more closely approached as underlying facts and principles are revealed.

FRUITS AND NUTS

Varietal improvement.—Continuing its productive work in the field of fruit breeding, the New York State station in cooperation with the Department (B.P.I.) distributed for trial the following new varieties of fruit: Alton, Dunning, Greendale, Redfield, Redford, Redhook, and Webster apples; Caywood and Covert pears; Sodus sweet cherry; Athens, Buffalo, Eden, and Kendaia grapes; and the Dresden strawberry. Two of the apples, Redford and Redfield, have primary value as ornamental trees because of their showy flowers and intense red fruits with red flush.

The extent of the grape-breeding enterprise conducted by the California station is indicated in the fact that over 8,000 seedlings have been planted in vineyard form since 1933. Some of these are very promising and are being widely tested in the State as to their commercial value. Certain vigorous triploid seedlings developed by the station show promise as rootstocks for established varieties.

The Ruddy raspberry developed by the North Dakota station from a cross of Latham by Plum Farmer was reported by the station to be vigorous, hardy, and tolerant to drought and red spider.

Starting some years back with selfed seedlings of the Van Fleet raspberry, the Tennessee station by repeated backcrossing with cultivated varieties made substantial progress in the development of good-quality red raspberries adapted to southern environments. Several promising seedlings have been distributed to growers for trial and at least one fall-fruited selection is considered of sufficient value for naming and introduction.

At the Connecticut (State) station, two promising strawberry seedlings were named Shelton and Hebron and distributed to growers of the State for trial.

Continuance by the New Jersey station of its strawberry-breeding project resulted in the selection in 1939 of many promising seedlings for further observation. Two of the earlier seedlings, Pathfinder and New Jersey 225, given wide trial by growers, were favorably received. Pathfinder has peculiar significance because of its resistance to red-stem root rot, a new and destructive disease. Two new varieties of peach, Fireglow and Pacemaker, were named by the station and will be increased and distributed by the New Jersey Peach Council.

Three new strawberry varieties—Daybreak, Eleanor Roosevelt, and Fairmore—were distributed by the North Carolina station as a contribution from breeding studies conducted jointly with the Department (B.P.I.).

As a result of breeding work, the Texas station released three new strawberries—Ranger, Alamo, and Riogrand. These combine ability to withstand high temperatures and to develop runner plants under irrigation. Ranger is notable for firmness and deep red color. Alamo and Riogrand are said to be of better dessert quality than Klondike and Missionary.

Two new almonds—Jordanelo of the Jordan type and Harpareil of the Ne Plus Ultra type—both developments of breeding studies conducted cooperatively by the California station and the Department (B.P.I.), were given extensive trial in commercial orchards. Both are conceded to be superior in several respects to existing varieties. The Jordanelo is expected to enter certain markets for which California has previously had no nut of the proper characteristics. The Harpareil because of its better quality than Ne Plus Ultra should prove a valuable commercial variety.

Pollination requirements.—The California station cooperating with the Department (B.P.I.), showed that pollen of many fruits including the apricot, peach, nectarine, plum, cherry, almond, pear, apple, and quince, may be kept in a living condition for a longer period under favorable temperature and air-moisture conditions. After 550 days, air-dry pollen which had been held at about 36° F. and at 25 percent relative humidity in sealed form showed good viability in almost every case.

Continuing its work on the pollination problem in apples, the New Hampshire station found in general that the McIntosh was a satisfactory pollinizer for its seedlings, such as Melba, Milton, Early McIntosh, and Cortland, and reciprocally that these varieties can pollinate McIntosh satisfactorily. However, when Early McIntosh was crossed with Cortland or vice versa there was a very low set of fruit. Microscopic observations on flowers showed that pollen tubes in either case would proceed no further than one-quarter the distance required to effect fertilization. Knowledge of such cases of incompatibility are valuable in aiding the wise selection of varieties for orchards.

That inbreeding or self-pollination is not a logical means of developing new apple varieties was indicated in studies conducted over many years by the Illinois station. Of over 5,000 seeds obtained by self-pollination, less than one-third germinated and more than half of the seedlings died or were discarded shortly.

That self-pollination of highbush blueberries may result in diminished yields and returns was indicated in studies conducted by the New Jersey station. In several instances the percentage of total flowers self-pollinated that set fruit was not significantly different from cross-pollination, but in almost every case the berries resulting from selfing were distinctly smaller than those resulting from cross-pollination. Often the self-pollinated berries were too small to be rated as of commercially desirable size. On the whole, the number of seeds per berry was roughly proportional to size of berry.

As indicated in studies conducted by the Iowa station, pollen abortion in the Winesap apple is apparently associated with abnormal development of tapetal tissue and pollen-sac wall cells. Tapetal tissue, instead of diminishing, continues its development to the extent that it crowds in upon the pollen and, in extreme cases, practically fills the locule, leaving little room for pollen development. In such cases the pollen shows evidence of abortion in lack of density and a vacuolated condition of the protoplasm and ultimate shriveling and disorganization. Apparently, pollen abortion in the Winesap is the result of a reversal in physiological relationships in which the tapetal cells digest the pollen.

Evidence that copper sprays and dusts when applied to apple trees in bloom may not be as injurious as would be indicated by their composition was suggested in carefully controlled studies carried out by the New York (Cornell) station. Paired blooms or single spurs of Northern Spy were pollinated with Delicious and treated at different times with respect to pollination with the chemicals. There was some indication that treatments prior to pollination were more hazardous than at the time of pollination or a day later.

The desirability of growing a sufficient number of varieties of cultivated blueberries to provide for cross-pollination was indicated in studies conducted by the New Jersey station under controlled conditions in the field. Although the percentage of total flowers to set fruits was much the same in self- as in cross-pollinations, the individual fruits were, in almost every case, smaller in the self-pollinations. The difference in size was sufficient, in many cases, to put the selfed berries in a less desirable commercial grade. Furthermore, the small berries resulting from selfing were often green at the time the larger, cross-pollinated berries were mature. In one or two crosses there was an indication of cross-incompatibility.

Genetic studies.—Based on the study of the original and progeny trees of an apple variety almost identical to Northern Spy in outward appearance but producing a great diversity in form, time of ripening, and color distribution, the Michigan station concluded that this particular variety is a chimera in nature. Since the variations were not limited to a single feature, the term "heterochimeric" is suggested as applicable to the new apple, named "Graham." It is suggested that various varieties now commonly grown, especially those that exhibit considerable variability, may be chimeras.

The almost complete prevalence of cross-sterility in hybrid plum varieties was indicated in results secured by the Texas station with 15,000-odd pollinations involving 54 crosses among 16 varieties.

In a study of seedlings resulting from the crossing of Antonovka, an apple of Russian origin and valuable because of its vigor and hardiness and capacity to transmit these characters to its progeny, it was found by the Iowa station that when pollen parents of good quality such as Jonathan and Delicious were used, the quality of the progeny was better than that of Antonovka itself and better than when Antonovka was crossed with inferior varieties. In other words, quality in the parents was essential to the development of good quality in the seedling.

Propagation.—The need of afterripening, at low temperature under moist conditions, the seeds of apple, pear, peach, and cherry was

shown in studies conducted by the Maryland station. None of several treatments, such as immersion in warm water, acid treatment, or exposure to ether, proved of any value in hastening the afterripening of apple and pear seeds. Catalase activity increased progressively until the seeds were fully afterripened, attaining at that time nearly twice the activity of untreated seeds.

That several varieties of apples in addition to Grimes Golden grow well when top-worked on Virginia Crab, a highly desirable stock because of its disease and low temperature resistance, was shown in studies by the Indiana station. Measurements were taken on 12 trees each of 9 varieties. Only 1 variety, Blaxtaman, showed a lack of affinity with Virginia Crab.

Ten years' records taken by the Massachusetts station on a planting of Wealthy and McIntosh apple trees established on eight rootstocks, including clonal, seedling, and own-rooted material, showed wide differences in the effects of the roots on the growth and fruitings of the scions. There was no definite indication that the clonal rootstock promoted greater uniformity of the trees than was obtained with seedling stocks. However, the use of known rootstocks gave a measure of control of size of tree and of the initiation of fruit bearing.

The importance of selecting strong, vigorous-growing apple seedlings for budding or grafting was indicated in studies conducted by the Michigan station. Differences observed in the seedling year were maintained through the second year in the budded whip and during the first 2 years in the orchard. Neither the period of maximum growth nor the time of cessation of growth was affected by size of the seedling upon which buds were placed, but the amount of growth was influenced significantly. The size of the apple from which seeds were collected had no direct influence on the size of resulting seedlings. Observations on apple trees gave evidence that differences in size of trees at time of setting in the orchard were maintained throughout a 15-year period.

Observations by the Michigan station on Early Richmond cherry trees planted in 1931, part on mahaleb and part on morello roots, showed the mahaleb-rooted trees to be upright-spreading in form with relatively thick branches and shoots, whereas the morello-rooted trees had assumed, to a certain extent, the natural growth habit of the morello. Measurements at the end of the seventh season showed trees on mahaleb to average 14.3 inches in trunk circumference as compared with 8.5 inches for the morello-rooted trees. Tree spread and width were also markedly less in the case of the morello-rooted group.

The value of certain vigorous native species of grapes as understocks for cultivated varieties of vinifera grapes was shown in studies conducted by the Texas station at Winter Haven where three serious pests, phylloxera, root rot, and nematodes, menace successful grape growing. The native species differed greatly in their congeniality with cultivated varieties, but there was promise that successful combinations could be established by extensive trials.

That the grafting of grape varieties on rootstocks may cause certain changes in composition of the fruit as compared with that of the same varieties on their own roots was indicated in studies conducted by the Arkansas station. The juices of Moore Early and Campbell

Early grown on certain rootstocks were definitely lower in sugar and higher in acid than juices from the same varieties on their own roots. On the other hand, Concord grapes were apparently little affected in composition by the rootstock.

That the type of rootstock employed in citrus propagation may exert a notable influence on the composition of the fruits was indicated in studies conducted by the California station with young bearing trees of Valencia and Washington Navel oranges, Marsh grapefruit, Lisbon and Eureka lemons, and Bearss lime, all budded on sour orange, sweet orange, rough lemon, grapefruit, and trifoliolate orange roots. Trifoliolate orange, the most dwarfing of the several stocks, produced the highest percentage of soluble solids in the juice in all cases. Rough lemon, the most vigorous stock, produced the lowest soluble-solids content. Both species influenced acid content of the fruits in the same manner as soluble solids.

In another rootstock study the California station found that sweet orange was a desirable rootstock for Eureka and Lisbon lemons. Type of soil was also concerned, the results indicating that the sour orange and the rough lemon stocks were apparently much better adapted to light than to heavy soils. On sour orange roots in heavy soil both Eureka and Lisbon showed a large percentage of trees affected with lemon decline, whereas on light sandy soils both varieties on sour orange showed very little evidence of this defect.

An association between the kind of rootstock and the prevalence and severity of granulation in the fruit was noted by the California station in a study of Valencia oranges grown on nine different rootstocks. At Riverside, rough lemon- and trifoliolate orange-rooted trees produced by far more granulated fruits than any other rootstocks. Irrigation was also a factor, abundant water causing increased granulation.

In the hope of reducing the time required to secure good root development in hardwood blueberry cuttings, cuttings of certain named varieties were treated by the Michigan station with various proprietary growth-promoting substances. The results were such as to lead to the conclusion that the materials under trial were of little value in hastening root formation in the blueberry.

Improved cultural practices.—Examination by the Pennsylvania station of soil collected from orchards under clean cultivation, cover crops, and sod, as well as from nearby fields, forests, and fence rows, indicated that the various systems of management had brought about measurable differences in carbon and nitrogen contents and in volume weight of the soils. Sod culture was definitely superior, as far as fertility was concerned, to either clean cultivation or the use of annual cover crops. In fact, the use of sods increased the total nitrogen content above that of forest soil. The low volume weight and associated high porosity and high permeability of orchard soils was maintained by leguminous covers and by grass sods. The practice of clean cultivation without cover crops was found to be a soil-depleting system attended by large losses of organic carbon and total nitrogen. Sod-forming covers, either permanent or occasionally torn up, are conceded to be the most satisfactory means of maintaining the fundamental soil qualities that lead to sustained productivity.

Based on observations of the rapid loss, during severe rains, of surface soil from orchards of moderate slope under annual cultivation, and on the inability to build up organic matter content by supplying supplemented chopped green forage, the Pennsylvania station concluded that both climate and cultural practices are concerned in the maintenance of organic matter. The need of securing more complete climatological data for experimental areas and of establishing a more uniform system of reporting soil nitrogen and organic matter was indicated. Only with such records is it possible to obtain an understanding of the interrelation of climate, culture, soil, and tree growth.

In a study of the atmospheres of sandy loam, light silty clay, and silty clay subsoils, the New York (Cornell) station reported that only the sandy loams maintained high percentages of oxygen throughout both the dormant and growing seasons at all depths down to 6 feet. The percentage of oxygen decreased with the depth in all three types, and in the silty clay it was impossible to obtain any gas samples from the end of November to the middle of June. Apparently, in the heavier soil roots at the deeper levels are inactive during a considerable portion of the year.

In the Champlain Valley fruit section of New York, the deepest-rooted, largest, and most thrifty trees were observed by the New York (Cornell) station to be located where the soil profile was of a fairly uniform texture and brown in color, usually bright and uniform as in the Alton series, but sometimes with slight grayness and mottling as in the Vergennes. In certain localities the presence of bedrock or a very compact unweathered glacial till through which apple roots did not penetrate to any extent interfered with the successful establishment and maintenance of orchards.

As shown by studies of the New York (Cornell) station in the Finger Lakes section, soil conditions exert a profound influence on the tree and its roots. Trees on loamy fine sand developed deep and extensive roots and vigorous tops. Where the surface soil was underlain with extremely compact unweathered glacial till subsoil or where bedrock came closer than within 3 feet of the surface, tree growth was limited and in very dry periods trees suffered severely. The importance of examining soils prior to establishing orchards is emphasized.

The importance of careful selection of orchard sites was indicated in a survey conducted by the West Virginia station of the soils in representative orchards in the eastern Panhandle area. Roughly grouping the soils into limestone and shale types, it was observed that the trees were larger and more productive on the limestone areas. Analyses of the soils to a depth of 8 inches showed the limestones to be somewhat higher in available phosphorus, organic matter, exchangeable potassium, and less acid as measured by determinations of the pH values. Cover crops grew more readily on the limestone soils.

Investigations by the Ohio station indicated that a combination of unfavorable factors, including a short, moist growing season in 1935, an early October frost which injured leaves, and a very rapid drop in temperature late in the following January, operated to effect very drastic injury to apples, peaches, and other fruits. It is suggested

that careful selection of orchard sites, use of hardy rootstocks, and better management practices in general would tend to reduce the hazards of extreme winters.

That peat moss may be a valuable supplement to soil used for growing young fruit trees was indicated in studies conducted by the New York State station. Using glass-sided boxes, it was possible to trace the course of root development. The best results from peat moss were secured under conditions simulating seasons of adequate or excessive early-season moisture, followed by medium or below-medium midseason moisture. The moss was apparently beneficial for several reasons, including improved aeration in early season, better contact of roots with moisture following planting, and easier penetration by the growing roots.

Marked increase in the size of apples produced by trees growing on deep porous loess soil was found by the Nebraska station to result from supplemental irrigation. General appearance of the trees and fruit was much superior on the irrigated plats. Evidence was obtained that the rainfall occurring in the area was inadequate to meet the needs of the trees and ground cover, and, as a result, there was a gradual lowering of the water table in the nonirrigated portions of the orchard.

The observation that pears were firmer from experimental plats where the readily available soil moisture was exhausted several weeks before harvest than from abundantly watered plats is thought by the California station to be an explanation of the comparatively late ripening of pears in certain nonirrigated sections. Differences in maturity as related to differences in soil moisture did not hold in the cool coastal districts.

That the character of the soil has a marked influence on the distribution of roots was indicated in observations made by the Ohio station in trenches dug beneath 10- to 12-year-old Elberta peach trees located on four different soil types. The better the drainage conditions, the greater the number of larger roots found at considerable depths. Injury in the disastrous winter of 1935-36 was greater in trees on the poorer-drained types of soil.

Certain studies conducted by the Georgia station on the root development of young peach trees planted in a rather heavy soil showed an unusual capacity for roots to penetrate stiff subsoils. By far the greatest quantity of small roots per unit of soil was found within 1 foot of the trunk, although the roots spread considerably farther from the trunk than did the branches. The observations are helpful in formulating fertilizer and cultural treatments for young peach trees.

A study by the Illinois station of the relation of temperature to peach production showed that there had been in the 105 years covered by records, 11 years in which low winter temperature had caused severe tree injury and complete loss of crop throughout the State. There was no regular sequence of disastrous years. Losses due to spring freezes were greater in the northern part of the State, suggesting that with present varieties peach culture has been carried too far north in Illinois.

Water requirements of prunes and walnuts, according to investigation by the California station, are just as well satisfied when the

moisture in the upper 6 feet of soil is allowed to reach the permanent wilting percentage before irrigating as when water is supplied so frequently that the surface does not dry out between irrigations. There were no significant differences in yield or in quality of the fruit from the contrasting plats. In irrigation trials with wine grapes, the quality of the wine made from grapes produced on irrigated and nonirrigated plats was substantially the same.

An examination in 1938 by the Ohio station of the root systems of black raspberries set in the spring of 1931, and handled part under straw mulch and part under clean cultivation, showed no significant differences in depth of rooting that could be associated with type of culture. There was some tendency for fibrous roots to develop just below the mulch and in the partly decomposed material, but to a lesser degree than occurs in apple trees. The total number of roots was larger under cultivation than under mulch. There was a decreasing gradient in the number of roots of all sizes from the surface foot downward.

The superiority of early-formed runner plants of the strawberry over those produced later in the season was reported by the North Carolina station. The early-formed plants produced almost twice as much fruit the following spring.

The protection of Blakemore strawberries by a straw mulch in winter and early spring was found by the Arkansas station to result in materially increased yields. The differences could not be accounted for solely on the basis of plant loss but appeared to be the result of protection to the crowns in the winter months and to the flowers just before and during bloom when killing frosts occurred in both the 1937 and 1938 seasons.

Tests by the Minnesota station of various materials for mulching strawberry beds led to the conclusion that the physical condition of the mulch is more important than the material itself. For example, peat moss was highly effective when dry but when it became wet, packed, and frozen, it lost most of its effectiveness. Loose snow in itself was an excellent mulch. Of various materials tested, a mulch of mixed leaves appeared most effective because it was least influenced by environmental conditions.

As observed by the Maryland station, Blakemore plants growing in a sandy loam showed well-defined responses to spacing and fertilizer treatments. Plants from thinned rows developed larger roots and crowns as compared with those from matted rows. Fertilizers applied in mid-August or mid-September were effective in increasing the dry-matter content of the roots. The longer continuance of growth of the plants in thinned rows is believed to account in part for their better fruiting performance.

Studies by the Massachusetts station in the improvement of wild high-bush blueberries showed that the removal of competing trees and vegetation increased growth. Moderate pruning and the use of fertilizers, particularly nitrogen, increased growth and yields. Fertilized bushes showed a marked tendency to annual bearing. Any treatment that increased terminal shoot growth up to about 10 inches increased yield.

Some promising results were secured by the Massachusetts station in the use of wind machines to protect cranberry bogs from frost.

A 40-horsepower motor, equipped with a large propeller housed so as to draw air from above, raised the temperature of the air above the machine to a distance of 300 feet sufficient to protect a 6-acre plat.

As reported by the Florida station, the Augusta vetch is proving a valuable winter legume cover crop for pecan orchards in northern Florida. In experiments where legumes had been turned under for several years, the pecan trees retained their foliage during a dry period in 1938 while in sections well fertilized but with no cover crops the trees lost most of their leaves.

Studies by the California station of the irrigation requirements of date palms indicated that the amount of water required and frequency of application varies with the season and with the soil type. On sandy types, there was need of more frequent irrigation than on the finer, more retentive soils.

Failure to select good-quality soil or to provide cultivation during the first few years following planting was disastrous to tung-oil plantations, according to observations by the Mississippi station. Root injury incident to shallow cultivation was greatly offset by the beneficial effect of weed removal. Tung nuts from different trees were found to vary from 17 to over 25 percent in oil content. Yields also varied greatly, indicating the need of breeding and selection work, which is reported in progress.

In a study by the University of Puerto Rico station of the root systems of six 7-year-old coffee trees, 94 percent of the roots were found in the top foot of soil and 99 percent in the upper 2-foot zone. The vertical penetration was 3 feet and the lateral extension 4 feet. A heavy and vigorous coffee-tree top was apparently not dependent on an extensive root system. Studies of shade requirements gave further evidence that one-third total radiation is better than larger amounts. Plants receiving one-third radiation made greater height and lateral growth and greater trunk increment than those receiving more light. The evidence to date indicates that coffee plants require partial shading and that the best degree of solar radiation is supplied by two-thirds shading.

Better use of fertilizers.—The lateral movement of potassium in the soil was demonstrated by the Ohio station when it was supplied to apple trees by means of holes bored to a depth of 18 inches. Samples of soil collected at the end of 3 years showed that the potassium had moved on the average 6 to 8 inches. A practical method of supplying potassium to deep-rooted fruit trees was indicated.

Reporting on the results of experiments extending over a 5-year period, the Idaho station stated that no significant benefit to apple trees followed the application of nitrogen, phosphorus, or potassium, either singly or in combination. Ammonium sulfate applied to Italian prunes in the Boise Valley increased both yields and growth, 1 pound per tree being nearly as effective as larger applications up to 6 pounds per tree. In the Payette Valley ammonium sulfate increased the yields of Italian prunes over the unfertilized checks, but there was no conclusive evidence of benefit from either phosphorus or potassium. None of the fertilizer treatments had any apparent effect on the quality of the fruit of either the apple or prune. It is concluded that the use of commercial fertilizers in southern Idaho prune and apple orchards should be restricted to those orchards in which preliminary tests show definite responses.

The importance of potash in the fertilization of coffee was indicated in investigations conducted by the Hawaii station. In two trials potash used in conjunction with nitrogen gave increased yields over nitrogen used alone or with phosphorus. No responses were received from the use of phosphatic fertilizers. The potash-fertilized trees contained higher percentages of potassium in all tree parts and the new growth contained higher percentages of starch.

On a coarse Norfolk sand, typical of the sand-hills area, the South Carolina station recorded very definite effects of nutrient deficiencies on the growth and yield of Elberta peach trees. A complete fertilizer containing nitrogen, phosphorus, and potassium produced significantly larger yields. Lack of potassium was particularly serious, resulting in a small crop of inferior fruits, and, as the trees grew older, in severe symptoms on the foliage. A lack of phosphorus did not produce such striking effects, but growth as measured in trunk increase was reduced.

Further evidence was obtained by the Colorado station that even under the semiarid conditions where cherries are usually grown in the State, Montmorency cherry trees are benefited by applications of nitrogen either as ammonium sulfate or as stable manure.

Further evidence was secured by the New Hampshire station that nitrate of soda and other sodium-containing fertilizing materials are harmful to the strawberry plant under certain conditions. In every instance where sodium was used in fertilizers applied in late July or early August, the yields the succeeding spring were significantly decreased. Apparently, sodium salts were injurious to the newly forming roots, particularly when applied in summer when the new runner plants are forming.

As reported by the Maine station, lime applied at the rate of 1, 2, 3, or 6 tons per acre for 1, 2, and 3 successive years to lowbush blueberries failed to show any detrimental effects, even where a total of 18 tons was applied over the 3-year period. In fact, most of the limed plants showed notable increases in yield. The top inch of soil from the 18-ton plats was found to be slightly alkaline, and a composite sample of the upper 6 inches showed a change from about pH 5 to pH 6.6.

The possibility of greater economy in the use of nitrogen, the most expensive single item in the annual fertilizer program of the citrus grower, was indicated in studies conducted by the California station. A low maintained supply of nitrate nitrogen was found sufficient for growth and production and made for better quality of fruit. The practical deduction was that small frequent doses of nitrogen should be preferable to heavy single applications. The maximum intake of nitrate by young citrus trees was found to be coincident with periods of greatest root and top growth.

Fruit thinning.—Using halves of the same tree, the Ohio station studied the effects on subsequent blooming of thinning young apple fruits approximately 3 weeks after petal fall and 6 to 7 weeks after petal fall. In all cases, the early thinning proved effective in promoting annual bearing. Delayed thinning, on the other hand, was associated with a very marked reduction in fruiting the following year.

Blossom thinning, as a means of promoting annual fruiting, was successfully employed by the New Jersey station in the case of ma-

ture Wealthy apple trees which had assumed the biennial habit. As a result of removing all flowers from weak spurs and axillary and terminal clusters, and thinning the stronger clusters to stand 10 to 12 inches apart, leaf area per spur was increased and new flower buds formed on a considerable percentage of spurs. In the following year, the blossom-thinned tree set a good crop as compared with no crop on the unthinned control trees.

Studies by the New York State station over a 3-year period with Elberta trees 6 years of age at the beginning, indicated that the stage of development of the fruit is a better index to time for thinning peaches than are calendar dates. In the first two seasons, thinning at any time failed to increase total yields but improved the size and color of the fruit. However, when the third season, a poor crop year, was included, the trees thinned in the early stage out-yielded the others so that the total yields were actually larger. Because of the better market quality of peaches from thinned trees in all 3 years, monetary returns were significantly greater.

Physiological studies.—The importance of adequate aeration of the soil for root growth of fruit trees was demonstrated by the New York (Cornell) station in studies with apple seedlings grown in the greenhouse under controlled conditions. Roots did not grow normally at oxygen concentration below 10 percent, and at 3 percent merely existed with little or no development. The results have a practical significance, indicating the importance of planting trees on well-drained sites.

Working with yearling trees of Yellow Transparent, Delicious, and Jonathan apples, the Idaho station observed that injury, as by girdling, to the phloem immediately above a dormant bud invariably resulted in the development of a narrow-angled branch issuing from the bud. The assumption was that wide-angled crotches result from the action of a plant hormone formed in the growing tips of the plant and passed downward through the phloem. When indolebutyric acid in lanolin paste was applied to the upper surface of the basal internode of a young shoot while the internode was still elongating, a marked increase was observed in the angle formed by the shoot and the trunk. After elongation had ceased and the tissues had hardened, neither girdling nor auxin treatment influenced the crotch angle. By permitting indolebutyric acid to diffuse slowly into the cut end of dormant whips that had been headed to about 30 inches, it was possible to cause abnormally wide angles throughout the entire tree.

As observed by the Missouri station, the immersion of unbranched yearling Jonathan trees in aqueous solutions of thiourea, followed by different disbudding treatments, retarded the development of distal buds so that the upper branches were not dominant the first year. The cutting back of 4-year-old Delicious trees resulted, in some cases, in the lower laterals outgrowing the terminal. A lack of sufficient water and reduction of light to 380 footcandles or the development of several shoots favored inhibition of laterals in cut-back trees. The more rapid enlargement of the trunk than of the young scaffold branches apparently forced the widening of the angle while the tissues of the lateral were still soft.

Attempts by the Missouri station to increase the carbohydrate reserves and thereby the resistance of the trunk and lower branches of bearing apple trees to freezing injury were unsuccessful. No significant change in carbohydrates could be determined either chemically or microscopically. There was some indication that the smaller amount of elaborated food moving on the upper side of the main branches may, by delaying maturity, be a factor in crotch injury. Tissue in wide-angled crotches apparently matures earlier and is therefore less susceptible to injury.

That there is no material difference in the inherent capacity to assimilate carbon dioxide of comparable leaves on thin and on thick branches was shown by the Rhode Island station in studies on a vigorous 25-year-old McIntosh apple tree. Apparently, exposure to light may be a determining factor in carbon dioxide assimilation in some instances.

Microscopic examination by the Montana station of the fruit tissues of Stayman Winesap, a variety of apple highly susceptible to cracking, and of Grimes Golden and Winter Banana, varieties of known resistance, showed definite tendencies for premature cessation or retardation of growth in the surface tissues of the susceptible kind. The station suggests that the susceptibility of Stayman Winesap to cracking is related directly to the observed phenomenon.

In studies by the Massachusetts station there was noted a moderate but significant correlation between seed number and time of preharvest dropping in the McIntosh apple. Seed content varied widely among trees, probably as a result of variability in pollination, but this did not seem to alter appreciably its association with the date of drop.

That peach fruits may continue to develop and attain marketable maturity despite spring freezes sufficient to kill the embryo was reported by the Ohio station. There was severe dropping shortly after the freeze. No difference was noted in the time of ripening of fruits with or without living seeds, but there was a tendency for fruits with dead embryos to be smaller than perfect fruits.

Seeking a means of reducing losses from the cracking of sweet cherries as they approach maturity on the tree, the Idaho station tested various sprays and found that bordeaux mixture, hydrated lime, and calcium acetate all greatly decreased the susceptibility of Bing, Lambert, and Napoleon cherries to cracking. Lime appeared to be the potent factor since equally good results were obtained with hydrated lime alone as with bordeaux mixture. It was evident that only the dissolved portion of the calcium is effective, since a saturated solution of hydrated lime was just as effective as a solution containing excess amounts.

That strawberry varieties differ greatly in their response to low-temperature hardening treatments was indicated in controlled-temperature experiments conducted by the Minnesota station. Alternation of low-temperature treatments from 0° to 20° C. was more effective in hardening than was continuous exposure to 0°, provided that 12 hours at 0° preceded the hardness tests. Plants watered abundantly were less hardy than those watered sparingly.

In determinations by the California station on different portions of oranges there were instances where a single segment of a fruit con-

tained much less total soluble solids than its adjacent companion sections. This variation offers an explanation of localized freezing injury. Differences noted in the composition of fruits harvested from different portions of a single tree emphasized the need of great care in selecting material for analysis or for observation as to maturity.

Observations by the California station throughout the year on the occurrence of starch in different portions of avocado trees showed the maximum content in the tree as a whole to be reached in mid-winter and the minimum in late summer or early autumn. Starch content was much lower throughout the summer and autumn in bearing than in nonbearing trees. Studies of starch changes throughout the year in avocado trees showed one well-defined maximum in late winter and a minimum in late summer or early autumn. Trees with a large crop followed the same cycle but had much less starch throughout the summer and autumn than nonfruiting trees. Readily detectable amounts of starch were observed at all times.

Storage and handling.—Better keeping of McIntosh and Northwestern Greening apples was recorded by the New York (Cornell) station in the case of fruits stored in airtight containers in which the atmosphere had been modified to include 5 percent of carbon dioxide and 2.5 percent of oxygen rather than the usual air. Under gas-storage conditions a temperature of 40° F. proved more satisfactory than 36° in preventing the development of brown core.

Grimes Golden and Golden Delicious apples coated with a thin layer of wax were found by the Maryland station to retain their turgid appearance better and to suffer less weight loss than untreated fruit. Holding the fruit of Grimes Golden for 1 week at moderate temperature between harvest and waxing was found desirable in reducing the amount of scald developing in storage. The intervening week was also helpful in avoiding the development of undesirable flavors often associated with waxing. In both varieties waxing retarded the development of yellow color following removal from storage, suggesting the desirability of permitting the fruit to attain a reasonable maturity before harvesting.

Studies by the Ohio station of the origin of mechanical injuries to apples indicated that the grading process is the most serious. The manner of emptying the picking container into the orchard crate was also important. Bruising occurring on the tree during growth was of minor significance. The practical suggestion is offered that sponge-rubber or other padding be used wherever possible in the bins and tables of the grading machines to reduce bruising hazards.

Stating that sun coloring of harvested apples is not new despite renewed interest, the Ohio station reported that the most striking color change from sun exposure was secured in McIntosh, with good results in Northern Spy and other varieties. Although there was some softening of apples in the open, there was no significant loss in keeping quality provided the fruit was stored immediately following sun coloring. The use of mulch appeared more practical than racks. Sun coloring was helpful in permitting the complete harvesting of the crop at one time.

Proper timing of the picking season would, according to observations by the New York State station, prevent the occurrence of

green-tinged flesh in the Kendall apple. Apparently, many growers have harvested this variety too early.

Continuing studies on the effect of ethylene in hastening the ripening of pears, the Oregon station found that the changes brought about by ethylene treatment were identical with those occurring during normal ripening. There was an increased rate of starch hydrolysis, higher sugar content, more rapid change of protopectin to pectin, and increased respiratory activity in ethylene-treated fruits. The increased rate of softening in ethylene-treated fruits was correlated definitely with increased rate of pectic changes.

Precooling of peaches prior to shipment was found by the Illinois station to be a valuable practice in the case of carlot movements. Ventilated packages equipped with ventilated liners expedited precooling and there was some indication of less decay than in tight packages. Temperature of the peaches, at the beginning of the precooling treatment, had a marked influence on the rate of cooling.

Comparing a short high-temperature treatment followed by cold storage with the present commercial methods of extended low-temperature processing, the Arizona station reports that, in general, high-heat treatments produced dates inferior to those processed at low temperatures. No significant differences were evident between high-heat treatments at 140° and 150° F. for periods of from 2 to 4 hours. High heat may be applied successfully to Halawy dates except when very dry. The treatment was moderately successful with dry Khadrawy dates. In only 1 of 5 years did the heat treatment prove successful with either Hayany or Maktoom. Moisture-proof containers retarded the formation of sugar crust and sugar spot but accelerated darkening and loss in flavor. Picking of early-ripening dates should be delayed until the translucent stage is reached.

Prestorage treatment of oranges in various concentrations of carbon dioxide gas was found by the Florida station to be effective in retarding the subsequent development of molds. High concentrations, 80 to 100 percent of carbon dioxide for 1 week before storage, reduced the amount of decay about 75 percent during the first month of storage, but later the decay was about the same in treated as in untreated lots. Long-time storage in concentrations of the gas above 5 to 10 percent caused soggy break-down and loss of fruits.

VEGETABLES

Development of varieties.—Definite progress was reported by the California station in its efforts to select types of onions that would not develop seedstalks prematurely. Two selections, Red 21 and Stockton G 36, the latter practically immune to premature bolting, were released for extended trial.

Trials by the Maryland station of a large number of varieties and strains of canning and garden peas indicated that certain of the so-called sweet varieties such as Dark Podded Thomas Laxton, Mardelah, and Pride may be grown successfully in the Eastern Shore area of Maryland. A few of these higher-quality varieties out-yielded the Alaska types. On the whole, the Alaska strains were fairly uniform in yield and in quality of product.

Summerset, a new home-garden tomato, developed by the Texas station, has proved very desirable in lengthening the fruiting season

for tomatoes in those parts of the State where irrigation is available. Its deep-red color and high quality make this variety a desirable source of juice and paste.

The New York State station produced a new variety of tomato, the Baerosa, from a cross of John Baer by Ponderosa. The new variety combines the best qualities of both parents.

Strain tests by the Pennsylvania station of Rutgers tomato plants secured from 16 different sources, including Southern States, failed to show any differences in total yield that could not be explained by the condition of the plants at time of setting in the field. There were, however, significant differences in early yield.

Superb Golden, a new hybrid muskmelon with Honey Dew as one parent, developed by the Michigan station, was found to require post-harvest storage for several days at 70° to 75° F. to attain maximum flavor and sugar content.

Of seven new varieties of hops tested by the New York State station, Brewer Gold and Bullion were particularly promising, the first-named variety outyielding by a wide margin all others in the test. Both varieties contained greater percentages of soft resins than any of the standard American varieties. The soft resins of the seven kinds under test ranged from 14.69 percent in Brewer Favorite to 26.72 percent in Bullion. Brewer Gold contained 22.58 percent.

Genetic studies.—The possibility of utilizing hybrid vigor as a means of increasing the production of cucumbers, particularly of early-season yields, was shown in studies conducted by the Minnesota station. In eight of nine crosses, the yield per plant in the first generation was significantly higher than that of the more productive parent. Most of the difference in favor of the progeny was produced in the first half of the picking season.

Working with the Yellow Bermuda variety, the Texas station found inbreeding effective as a means of securing greater uniformity in the onion and ridding the stock of certain undesirable attributes such as doubling and premature seeding. There was, however, some loss of size as a result of continued inbreeding.

In search of physical or anatomical characters that might be associated with drought resistance in corn inbreds, the Iowa station found that exposure of 20-day-old seedlings to certain controlled-temperature and relative-humidity conditions was a satisfactory means of distinguishing between resistant and susceptible lines. A temperature of 131° F. for 5 hours killed most of the susceptible sweet corn plants, whereas some of the resistant plants withstood 131° for 6 hours. Although transpiration rates of drought-susceptible inbreds were somewhat higher as a group, the difference was not of sufficient magnitude to serve for distinction. No significant difference was observed in the weight of roots of the two groups.

Detailed observations on the flowers of various cultivated forms of cucurbits led the Michigan station to conclude that temperature is by far the most important factor in determining anthesis and anther dehiscence. Wind movement and relative humidity appeared important largely as they in turn influenced temperature. On a basis of optimum temperatures for anthesis and dehiscence, the cucurbits under study could be grouped roughly into three divisions: (1) Pumpkins and squashes, (2) cucumbers, gherkins, and watermelons, and (3) cantaloups, Honey Dews, and Casabas.

The Michigan station was able to induce the formation of seedless fruits in the National Pickling cucumber, a variety that very rarely produces fruit without pollination, by the application of naphthalene acetic acid applied either as an aqueous solution or in the form of lanolin paste. Fruits were produced also by the same methods in the Harris Wonder pepper.

In genetic studies with the tomato, the California station found that male sterility was completely recessive and depended apparently on at least two recessive factors both of which were necessary to bring about the condition. It is suggested that some of the unfruitful plants that occur in commercial tomato varieties may be male-sterile segregates resulting from the selfing of fruitful and apparently normal heterozygous plants.

Noting considerable natural crossing in bush and pole varieties of garden beans in the field, the Alabama station planted varieties possessing sharply contrasting characters at various measured distances apart. The percentages of crossing decreased as the distance apart was increased, but even at 9 yards there was some crossing, suggesting the need in bean-seed production of isolating parental stocks by 50 yards or more.

Better cultural methods.—The placement of fertilizer in bands near the root area of lettuce was found by the Arizona station to be much more effective than broadcasting. Some of the benefits were greater uniformity in size and time of ripening of the heads, and placing the fertilizer where it was most useful to the plants.

Working under greenhouse conditions where soil moisture could be controlled, the Virginia Truck station found that with snap bean, cabbage, and pea seeds, placement of the fertilizer was a potent factor in seed injury. Moisture content of the soil was involved, as certain placements were much more injurious under low than abundant moisture conditions. Fertilizers placed 2 inches distant from the seed row and 2 inches below the seed were relatively harmless irrespective of soil-moisture content.

Studies conducted by the Virginia Truck station in cooperation with the Department (B.A.Engin.) showed the desirability in the case of Henderson Bush Lima beans of placing the fertilizer in narrow bands from 2 to 3 inches at each side of the seed row and from 1 to 2 inches below the seed level. The greatest profusion of blooms and rapidity and uniformity of plant growth and greatest yields resulted from placement 2 inches to each side of the row and 1 inch below the seed level. Fertilizers mixed with the soil or broadcast immediately before planting were more or less injurious, depending on the thoroughness of incorporation and the amount of soil moisture present during germination.

Of different methods of applying fertilizer to cabbage grown in rotation with sweet corn and winter rye tested by the New York State station, working in cooperation with the Department (B.A.Engin.), the most successful was that in which the fertilizer was applied, at the time of setting the plants, in bands 2.5 inches at each side of the row and from 3 to 4 inches below the surface. The application of 600 pounds per acre of 4-16-4 material produced profitable increments in yield each year. Rainfall during August and September was the most important single factor affecting the yield of cabbage.

That the detrimental effects of early cutting of newly established asparagus plants may continue for many years was reported by the Illinois station. Records taken over the years 1931-37 in a field of the Mary Washington variety established in 1926 showed the harmful effects of medium and heavy cutting in the first year following setting. Light cutting the second year was evidently not detrimental but, on the whole, the results suggested the advisability of deferring all cutting until the third year after setting. In well-established plantings cutting for 8 weeks, the spring of each year after the fourth year, gave good results and is considered good practice.

Crowns of Mary Washington asparagus collected at 15-day intervals throughout the year from fertility plats located on sandy soil were found by the South Carolina station to differ but slightly in their percentage content of sugars and starches. However, the roots from high-nitrogen plats were significantly higher in total nitrogen. Fall cutting of spears was definitely harmful, resulting in a lower carbohydrate reserve throughout the winter and spring. The need of maintaining vigorous top growth throughout the autumn was indicated.

Of varieties and strains of "Iceberg" (New York) lettuce tested by the New York (Cornell) station at several locations in the State, a hybrid known as Imperial 44, developed by the Department (B.P.I.), showed unusual capacity for producing firm, marketable heads even under conditions that greatly reduced heading in other varieties. Imperial 44 was slower to form flower heads than any other strain of the same type tested. As grown on well-decomposed muck soil, Imperial 44 had a much more spreading root system and fewer deep roots than White Boston, indicating a better feeding but possibly a poorer water-collecting capacity. It was concluded that wider spacing than is usually allotted lettuce was needed to produce large heads of the "Iceberg" type. Too abundant feeding with too quickly available nitrogen made for poorer heading and greater susceptibility to tipburn. Water supply was apparently a vital factor, and a plentiful and relatively constant supply is considered essential for good heading.

At Matanuska, the Alaska station found that garden peas of the Alaska variety failed to respond greatly to any of the principal fertilizer elements or to barnyard manure.

Of various fertilizer applications employed by the South Carolina station on snap beans, that which included 30 pounds of available nitrogen, 100 pounds of available phosphoric acid, and no potassium gave the most profitable yields. The use of from 50 to 100 pounds of available potassium significantly reduced the yields as compared with no potassium, this effect being ascribed to an accumulation from several years of intensive fertilization. Fertilizers having all the nitrogen in water-soluble form gave just as good yields as those in which part of the nitrogen was in water-insoluble form. The need of including manganese and magnesium in the fertilizer was indicated.

For celery growing on Everglades organic soils, the Florida station found potassium to be absolutely essential, since crops grown without applications of this element were practically valueless. Of trace elements, manganese was most commonly deficient, and zinc,

copper, and boron were often beneficial. Despite the high total nitrogen content of the soil, applications of available nitrogen proved profitable. The water table was an important factor, the best results being secured when kept at 16 to 24 inches after the plantings were established.

The practical difficulty of building up the organic-matter content of truck-crop soils in southern Alabama was indicated in studies by the Alabama station. After turning under five successive crops of crotalaria, the increment in organic content determined by the ignition method was negligible. However, crop yields were materially increased as a result of the decomposing cover crops, leading to the conclusion that there was a beneficial influence on biological activities in the soil which in turn brought about a higher state of fertility.

Forced by the ever decreasing supply of animal manures to seek new sources of fertilizing material for mushroom growing, the Pennsylvania station found that a synthetic compost of wheat straw, urea, and wheat produced nearly the same yields as horse manure. The droppings in horse manure were not considered essential since the total yields were practically alike whether droppings alone or bedding straw alone was used as a basis of the compost. The addition of wheat to the compost resulted in more rapid decomposition and larger yields than where no wheat was used. Rate of decomposition increased as urea was increased up to 32 pounds per ton of straw. Yields of mushrooms from synthetic composts per ton of straw and also per square foot of bed decreased as the amount of decomposition increased, due, apparently, to a loss in organic matter.

Analyses of the stems and petioles of vegetable plants grown on different soil types and under different nutrient conditions were found by the Virginia Truck station to give an accurate indication of nutrient needs whether due to actual lack in the soil or to inability of the plants to absorb certain nutrients. For example, nitrogen deficiency, in the presence of adequate supplies of other nutrients, resulted in an extremely high concentration of soluble phosphorus and a comparatively low concentration of both soluble and nitrate nitrogen in the tissues. A lack of phosphorus in the presence of adequate supplies of other essential nutrients resulted in an extremely low concentration of soluble phosphorus and usually in a very high concentration of nitrate nitrogen. In the case of potassium deficiency, there was found an extremely low concentration of potassium and usually a high concentration of soluble and nitrate nitrogen, magnesium, and calcium.

Studies by the Arkansas station of the soil-reaction preferences of various vegetables indicated that most species have rather definite optimum requirements. Potatoes, beans, peas, tomatoes, and watermelons apparently preferred an environment slightly below neutrality. Cantaloups and spinach thrived best when the soil was slightly on the alkaline side. Certain plants, such as the radish, appeared less exacting as to acidity requirements and grew well over a considerable range. Growth and production on unfavorable soil acidities were apparently retarded more by the inability of the plant to absorb certain nutrients than by direct influence of the soil reaction.

Physiological studies.—The importance of using balanced supplies of nutrients in growing vegetables was indicated in studies conducted by the New Hampshire station with the tomato plant. Chemical analyses of plants grown in sand with and without external supplies of potassium at different nitrogen levels, showed that the percentage of potassium in the ash was actually increased at the lower nitrogen levels. At the high-nitrogen levels a lack of potassium decidedly depressed growth, whereas at a very low nitrogen level a very low potassium level resulted in better growth than did a higher potassium level. No striking evidence was found that potassium deficiency produces abnormalities in nitrogen metabolism.

Observations by the New Jersey station on the growth of several tomato varieties under controlled root-temperature conditions showed considerable range in varietal response. Rutgers and other varieties with a high rate of metabolism were most adversely affected by high temperatures. Under root temperatures high enough to inhibit fruit setting in Rutgers, the starch present in the afternoon disappeared completely during the night and was absent from the pollen grains.

Analyses by the New Jersey station of tomatoes harvested in the green, yellow-ripe, and red-ripe stages from several fields showed a natural content of copper ranging from 9.8 to 22.3 parts per million. The higher the copper content of the soil the higher was the copper content of the fruits. There was a progressive increase in copper content with the maturation of the fruits.

In observations on fifty-odd varieties and strains of tomato, the Ohio station recorded a definite varietal response to environment with respect to the relative length of the pistils and stamens. The maximum length of pistils in relation to stamens was attained in plants grown under relatively short day length, light of low intensity, and an abundance of available nitrogen. This approximates greenhouse conditions in midwinter when poor setting of blooms occurs. On the contrary, short pistils in relation to stamens were produced under long day lengths, high-intensity light, and moderate supply of nitrogen, simulating conditions of early summer.

A successful method of obtaining strong germination in freshly harvested cucumber seeds, many of which show a tendency to delayed development, was discovered by the Arkansas station. Germination was improved notably by planting on moist absorbent material in a moist chamber at 86° F. and in some instances further improved by removal of seed coats. The finding is considered of particular significance in breeding studies.

Vernalization, or the low-temperature treatment, following a limited intake of water and the initiation of germination processes was found by the Maryland station to be of little significance in the growing of tomatoes. In the greenhouse the most effective treatments hastened the onset of ripening slightly but had no effect on total yields. In the field the response was very slight and of no practical significance, possibly because the long summer day and high light intensity may have resulted in a high degree of plant efficiency that masked any accelerating effect of vernalization treatments in the seedling stage.

Evidence that storage of lettuce seed at relatively high temperatures accompanied by low relative humidity may be an effective means

of breaking the dormant condition often observed in freshly harvested seed was secured by the Arizona station working with two selections of the "Iceberg" type lettuce. The information has value for plant breeders interested in the improvement of lettuce and for growers who may wish to replant within a few months following harvest.

Seeking knowledge of the factors concerned in the premature formation of seedstalks in spinach, the New York (Cornell) station concluded from experiments that day length, or photoperiod, may be less important than temperature in determining reproductive response. The day length necessary to cause the appearance of seedstalks was apparently determined by the temperatures obtaining during early growth complemented by those prevailing during later stages of development. The rate of elongation of seedstalks following their initiation was determined by prevailing sunshine, day length, and temperature in descending order of importance.

Storage and handling.—Subjecting cucumber and pepper fruits to controlled ranges of temperature and relative humidity, the New York (Cornell) station found that pitting of the surface may occur at all temperatures between 33° and 60° F. Relative humidity was concerned in that at the various temperatures pitting was decreased as the relative humidity was increased. Desiccation was not considered the initial cause of pitting but was simply the manifestation of cell injury resulting possibly from low temperature, mechanical injury, or suboxidation.

The dipping of carrots, beets, squash, cucumbers, tomatoes, peppers, and other vegetables in a cool wax emulsion was found by the New York (Cornell) station to leave a very thin film which reduced water losses and shriveling without having any harmful effect on flavor. Waxed vegetables kept from two to three times as long as the unwaxed before the onset of wilting and break-down.

ORNAMENTALS

Propagation.—The Ohio station, in studies of the effect of synthetic growth-promoting substances on the rooting and subsequent development of ornamental plants, noted that hardwood cuttings in general did not respond to treatment with indolebutyric and naphthaleneacetic acids. Treatment of softwood cuttings of greenhouse plants and woody ornamentals and mature cuttings of narrowleaf evergreens decreased the time required for rooting. In general, plants difficult to root by cuttings were not materially benefited by treatment. In most cases, the treatments caused more roots to be produced over a larger stem area. Apparently there was no consistent relation between the number of roots induced and their length.

Cultural methods.—The inclusion in certain types of clay and sandy soils of 25 percent by volume of peat was observed at the New York (Cornell) station to increase greatly the growth of flowering plants. Apparently, the amount of organic matter was related to the beneficial effects of fertilizer, for in certain types of soil, plants failed to respond to fertilizer unless organic materials were present.

Gravel culture with nutrient solutions is said by the Ohio station to have among others, the advantages of not requiring watering, weeding, cultivation, fertilization, and changing of the soil. In addi-

tion, the type of growth can be more or less controlled by changing the concentrations of nutrients. Soil-borne pests and diseases are absent, and in some cases better-quality blooms are produced. Among crops grown successfully were roses, carnations, chrysanthemums, sweet peas, snapdragons, begonias, and marigolds.

In studies with 19 species of annual garden flowers grown in soil varying in pH value from 4.5 to 7.5, the Virginia station found that all grew well at pH 7.5, suggesting that with the possible exception of phlox, petunia, lupine, and cornflower, the upper limits of favorable soil reaction were not reached. In general, a reaction of between pH 6 and 7 was most favorable. Sap analyses failed to reveal any instance in which the soil reaction induced a deficiency in calcium, magnesium, potassium, phosphorus, or nitrate or ammonia nitrogen. Calcium and potassium tended to increase in the sap as the pH value of the soil decreased, while magnesium increased as the pH value increased. Available iron, aluminum, and manganese increased in the soil with increasing soil acidity whereas the available phosphorus showed no correlation with soil reaction. The total amount of manganese in plants grown under the different treatments increased with a decrease in pH value, whereas aluminum and iron showed no such correlation. The indications were that aluminum was responsible for the detrimental effects of low soil pH value under the conditions of the experiment.

Working with carnations, an important commercial floral crop in the State, the Colorado station found that steam sterilization conducted under proper conditions did not reduce yields, lessen quality of bloom, or cause death of plants. Economically, sterilization has several advantages, including actual saving in costs as compared with annual renewal of the soil.

Cloth-covered houses were found by the Ohio station to offer an opportunity for the commercial production of summer flowers of superior quality. Under white cloth there was a reduction in light amounting to 35 percent and in temperature of from 5° to 8° F. The relative humidity under the cloth was somewhat higher than outside. Asters responded to shading with black cloth from 5 p. m. to 7 a. m., beginning from 7 to 8 weeks after planting. On the other hand, the use of supplemental light on asters in the seedling stage hastened flowering according to the variety grown. Under cloth, many annuals produced larger flowers with longer stems and better color. The shading of pompon chrysanthemums with black cloth from 5 p. m. to 7 a. m. resulted in earlier flower production. Roses produced under cloth were equal or superior to those grown in the greenhouse in summer. The cloth greenhouse proved desirable, also, for holding certain stock plants such as pelargoniums.

In a comprehensive study by the Iowa station of factors affecting the growth and development of gladiolus flowers, no shape or size of corm was found that could be associated with any definite qualitative flowering capacity. However, in most varieties low-crowned corms emerged from the soil in less time and produced more and taller spikes, greater total leaf area, and a greater number of florets per corm. Because of their larger size, low-crowned corms contained greater total reserves. They are believed preferable for forcing when light conditions are not at their best.

The use of ethylene as a means of defoliating roses and other nursery stock at the time of digging in autumn was found practical by the Oregon station. When used in moderate concentration no harmful effects followed and the plants matured normally.

Storage practices.—In investigations carried on under controlled conditions, the Iowa station found that carnation flowers stored without being placed in water were comparable with fresh blooms in keeping quality and carbohydrate reserves. Storage with stems in water was not found desirable because of poorer keeping and loss of carbohydrates. The blooms lost weight when moved to room temperatures. Good keeping was favored by high relative humidity. Carnations wilted prior to storing "dry pack" kept better than when stored in a turgid condition. A temperature of 33° F. proved better than 40° F. for holding cut flowers.

FORESTRY

Reproduction.—Observations by the New York (Cornell) station on the seed production of certain deciduous forest species growing in a mixed, second-growth, uneven-aged stand showed marked increases following treatment with nitrogen fertilizers. Maple responded more definitely than beech, not only in total amount of seed but also in percentage of sound seed and dry weight of individual seed. Total nitrogen content of leaves, recorded as percentage of dry weight, was considerably increased by the nitrogen treatments.

In studies of the root response of slash pine seedlings to indolebutyric acid, the Florida station observed greater survival, much longer taproots, and better lateral root development in nursery-grown seedlings planted following the treatment in a deep, moderately dry Norfolk sand than in the control trees.

A method for testing the germination of forest-tree seeds in sand, involving the use of partly sterile sand continuously supplied with moisture by subirrigation, was described by the Connecticut (State) station. The germination percentages of forest-tree seeds were practically equal to or higher than those obtained in soil or in oven germinators. In addition, there was less tendency to decay in the field.

Based on studies of samples of soil collected in the forest, in barren areas, and also on growth studies in the greenhouse, the Wisconsin station concluded that moderation in the use of readily available nitrogen is desirable in nurseries for growing forest-tree seedlings. Soils collected from beneath thrifty conifers showed a nitrogen-phosphorus-potassium ratio of about 1-2-5, and the greenhouse work suggested that the ratio should not exceed 2-2-5 NPK. Luxuriant vegetative growth may not be the most desirable status with respect to developing sturdy plants resistant to disease and unfavorable environments.

In a related study, the Wisconsin station observed that top dressings of organic matter discourage the downward movement of the roots of young forest-tree seedlings, thereby preventing their securing the supplies of other nutrients, chiefly phosphate and potassium, present in the soil at greater depths. In nursery practice, it is suggested that prior to planting the seed or seedlings a considerable

portion of the peat or duff should be incorporated in the soil by alternate plowing and disking or rototilling.

Species trials.—A resurvey by the Minnesota station of shelterbelts, which had been exposed to unusually severe climatic conditions during their 14 years of existence, showed great differences among tree species in their capacity to withstand adverse conditions. The four most successful species were green ash, boxelder, American elm, and caragana. Green ash was the outstanding species tested. Evergreens survived better on sandy than on heavy clay soils. Beyond question, soil moisture was the most important factor in determining survival.

Based on a study of 47 species of forest trees and shrubs on the Kellogg reforestation tract, the Michigan station classified plants into three groups: (1) Frost-hardy, (2) moderately hardy, and (3) not hardy. Frost hardiness was observed to be due to various factors, such as resistance of the new growth to freezing, delayed opening of the buds, and site. In susceptible species, frost injury was much more severe on lower slopes and valley lands than at higher elevations. It was evident that frosts may deform, weaken, or kill plants, and in some cases prevent or retard their establishment on a given site. As a practical suggestion, it is recommended that only hardy species be planted on low sites and that tender species be planted on upper slopes and ridges where there is less frost hazard.

Silvicultural requirements.—Observations by the Pennsylvania station on the development of Norway pines planted in the spring of 1921 at 5- by 5-, 6- by 6-, 6- by 8-, and 10- by 10-foot intervals showed in 1937 that crown closure had occurred on all but the 10- by 10-foot plat. Natural pruning up to a height of 8 feet had occurred on the 5- by 5-foot plat, with practically none on the 10 by 10. Branch diameters were over 50 percent larger on the 10 by 10 trees than on the more closely planted. The 10 by 10 trees were the tallest, with little difference in height between the trees on the other three plats. The average form quotient of the 10 by 10 trees was considerably lower than that of the other trees.

Based on several years' intensive study, the Indiana station suggested the exclusion of livestock as the first step in the management of farm woods in the better agricultural sections of the Central States. The rate of recovery was found dependent on the stage of decadence at the time the animals were excluded. Wooded areas of the open-park stage were unable to make successful progress toward rehabilitation until species which could successfully invade the sod had re-established conditions favorable to the germination and growth of the desirable species. The time required to progress from one stage of decadence to the next higher stage varied with the type of forest. It was most rapid in the wet upland type, followed closely by the beech-maple, and was very slow in the oak-hickory types. Soil moisture was evidently the most important limiting factor in the establishment and survival of natural reproduction. In the open-park woodlands during drought, soil moisture dropped below the minimum at which seedlings could survive. The responsible factors for low soil moisture are high transpiration rate of the trees and of the bluegrass sod, the absence of leaf litter, increased light intensity, and wind movement.

Working in a 25-year-old white pine plantation, trees spaced 6 by 6 feet, the Vermont station determined that both the type and season of pruning are concerned in the healing of the resulting wounds. Deliberate cutting of the branch base during removal of the branch resulted in callus formation. Some advantage in healing was gained also by wounding the branch bases of limbs which had been dead not more than 3 or 4 years. Early spring was the most favorable pruning season with respect to encouraging callus development.

AGRICULTURAL SOILS AND PLANT NUTRITION

CONTENTS

	Page		Page
Soil reaction and its control.....	67	Soil moisture and water movement.....	75
Mineral nutrients, fixation, and base exchange.....	68	Soil conservation and land use.....	76
Mineral deficiencies and toxicants.....	70	Soil profiles and soil structure, texture, and color.....	79
Organic matter and nitrogen.....	72		
Soil microbiology.....	74		

A knowledge and understanding of the basic physical, chemical, and biological principles controlling the practical behavior of agricultural soils is essential to the development of any sound system of soil management, conservation, and land use. This is especially true of systems which must fit into a program of adjusted agriculture. The State and Territorial experiment stations are meeting this pressing modern need with work on all the major problems which it presents. While much of this work is, of necessity, highly technical in character, all of it has been directed either toward immediately practical objectives or toward the securing of the essential basis of proven scientific fact on which alone permanent and economically sound solutions of these practical problems can be based.

SOIL REACTION AND ITS CONTROL

The effects injurious to crop plants resulting from acid soil reaction produced by the continued use of acid-forming fertilizers are receiving attention at an increasing number of the State experiment stations. At the Connecticut (State) station acid-forming fertilizers have been shown to increase the loss of such essential exchangeable bases as potassium, magnesium, calcium, etc. Suitable quantities of calcium carbonate, however, were shown to be capable of holding the soil at approximately its original reaction. At the Connecticut (Storrs) station limestone mixed with the plow layer or applied on the soil surface appreciably reduced the acidity of the lower layers. The limestone appeared to be itself gradually dissolved and carried down rather than to cause the leaching of exchangeable bases other than calcium into the lower layers at the expense of the surface-soil supply. At the Rhode Island station magnesian and calcic limestones and hydrated limes were about equally effective for neutralizing acidity in the plow slice. All four of these liming materials appreciably lowered the acidity in the 9- to 20-inch layer when applied at normal liming rates during 25 years. The two hydrated limes were slightly less effective in the subsoil than were the limestones.

By an improved method of determining soil alkalinity, it has been shown, at the Arizona station, that alkaline soils may be neutralized more simply and with the use of much less acidity than has heretofore been supposed to be possible. The Washington station has also obtained results which will aid in the practical application of soil-reaction data.

MINERAL NUTRIENTS, FIXATION, AND BASE EXCHANGE

A comparison at the Rhode Island station of calcic and magnesian liming materials has shown that, after 25 years of cropping and 9 years after the last liming of the soil, spinach contained only about two-thirds as much calcium after soil treatment with the magnesian materials as after calcic lime or limestone treatment. The calcium contents of tomato fruits and of potato tubers were not significantly different on the differently limed soils, but grasses and mixed hays grown on soils limed with the magnesian materials contained about 15 percent less calcium. The available calcium in the soil has been shown by the New Jersey station to be sometimes too low for optimum protein and carbohydrate synthesis in crop plants even when the soil reaction is satisfactory. An abundance of potassium in the soil may also prevent plants from absorbing sufficient calcium. A suitable ratio of available calcium to available potassium (or sodium) was found at this station to be extremely important for seed germination. At the Pennsylvania station many orchard soils were shown to be of such definitely higher replaceable potassium content in the surface soils than in the subsoils that a loss of topsoil by erosion increased the potassium requirement. Added magnesium and potassium sulfates caused increased leaching loss of calcium from soils at the Tennessee station, and additions of limestone had a like effect, but dolomite (magnesian limestone) caused little or no increase in calcium losses. About 60 percent of the magnesium sulfate added was lost by leaching, and somewhat more was lost when calcium and potassium sulfates were also added. Neither calcium or magnesium sulfates increased the leaching loss of potassium from this soil, despite an unusually high exchangeable potassium content.

The absorption and fixation of phosphates have been studied from various viewpoints. Subsurface soils absorbed, at the Kansas station, much more phosphate than did the top layers, and the subsurface soils usually showed the lowest phosphate availability. Heavily leached soils absorbed from two to five times as much phosphate, both in the surface and in the subsurface, as did corresponding layers of slightly leached soils. In two mineral soils and in a highly organic soil at the Delaware station, fixation of phosphates increased with increasing quantities of exchangeable calcium and increased also with decreasing acidity. Phosphates were fixed by these soils, however, even when the exchangeable bases had been removed. Fixation under the last-named conditions seems to have consisted in the formation of the almost wholly unavailable aluminum phosphates. Soil fixation of potassium in a form unavailable to plants increased in the inorganic soils, with increasing percentage of saturation with calcium, but the organic soil did not fix potassium. From the practical viewpoint, therefore, the percentage of calcium in the soil should be

kept high enough to prevent formation of the almost or quite useless iron and aluminum phosphates, but enough below complete calcium saturation to avoid fixation of phosphates by the calcium. Overliming would hold potassium, as well as phosphate, at a low level of availability. At the New Jersey station the phosphate-fixing soil complex was broken down by treating soils with calcium or magnesium silicate, and definitely increased yields were obtained. At the California station, soils containing the kaolinite type of clay fixed much more phosphate than did soils having a bentonite clay. The phosphate availability of the kaolinite clay increased with the percentage of saturation of the clay with the phosphate. Light applications of phosphate to soils containing a kaolinite clay would, therefore, be of little use. At the Nebraska station, the nitrification of urea or of ammonium sulfate lowered the alkalinity both of calcareous and noncalcareous alkaline soils, but these treatments increased phosphate availability only in the noncalcareous variety of alkaline soil. Crop residues and manures had little effect on alkalinity but did increase the available phosphate supply. It was concluded, however, that these organic materials increased the available phosphate supply more by releasing their own phosphate content than by increasing the solubility of the soil phosphates. Experiments at the Oregon station indicated that micro-organisms play an important part in the absorption and release of calcium and potassium as well as of nitrates. The concentration of soluble bases tended, in general, to parallel that of the nitrates. Water-soluble nutrients were most abundant in the surface soil, where there is the most organic matter and the greatest biological activity.

At the Maine station, magnesium as a component of commercial fertilizers has assumed such importance that determinations of both water-soluble and total magnesium are included in the regulatory analyses.

The perennial problem of the determination of the fertilizer and lime requirements of soils has been attacked from many directions and by many of the stations. This work, though for the most part of a highly technical character, has direct practical application in the economically sound maintenance or improvement of soil fertility. The New York (Cornell), Connecticut (State), California, Michigan, Illinois, Montana, and Wisconsin stations are among those which have contributed important studies of this type.

Fertilizers and fertilizer placement have been under investigation at most of the stations. The Massachusetts station has made progress in the reduction of the needlessly large number of commercial fertilizer grades. Of the total mixed-fertilizer tonnage sold in Massachusetts in 1938, 84 percent was of one of the "New England Standard Nine" grades or of a grade varying by not more than 1 percent in any element from one of these nine standard grades. As a result of an educational campaign by the Alabama station, that station is able to report the State's farmers as more interested than at any preceding time in using the most effective fertilizer. Improvements in grade of fertilizers sold and in the avoidance of damage due to acid-forming fertilizers were also observed.

At the New York State station the side-dressing placement of fertilizers has been found to avoid the leaching out of the fertilizer

before the end of the season, to prevent loss of phosphates and potassium salts by fixation in soils of high-fixation capacity, and to be of value to the grower who desires to know that a good stand has been secured before applying fertilizer. Phosphates applied in easily soluble forms at the Kansas station mostly remained in the top 4 inches of soil. When rock phosphate and manure were used and, to a lesser extent, when superphosphate was the source, the phosphates had reached a depth of from 2 to 3 feet during 27 years of top dressing for alfalfa. Rock phosphate was much less fixed by the soil than was superphosphate, and at from 1- to 2-foot depth the phosphate accumulated from rock phosphate was entirely soluble in dilute acids. Except in the surface 4 inches the soil accumulation of phosphate contributed by manures was mostly fixed in a difficultly soluble form, but a large part of the phosphate from this source was at once utilized by plants rather than accumulated in the soil in any form. Experiments made by the Virginia station in an overcrowded, ill-maintained orchard showed that cyanamide was three times as effective when applied with potassium sulfate, three and one-half times as effective when applied with superphosphate, and four times as effective when used with both the phosphate and potassium, as it was when cyanamide alone was applied. The combination improved both the condition of the trees and the vigor of the native ground cover. Fertilizer-placement studies have been reported from the South Carolina and other stations.

MINERAL DEFICIENCIES AND TOXICANTS

Work in plant physiology and plant pathology, insofar as it concerns trace-requirement elements necessary in agricultural soils, has here been included with other soil investigations.

A chlorosis of foliage has been shown at the Massachusetts station to be due to insufficient available iron. Chlorotic leaves of gardenia were restored to a normal green color by treatment with iron compounds but not by treatment with compounds of any of the other trace-requirement elements. The curative effect of iron compounds added to the soil was slow, but there was no response to any of the other trace-requirement elements. Fertilizers containing nitrates increased the chlorosis, but organic and ammonia nitrogen sources prevented the disease. Phosphatic and potassic fertilizers did not affect it. Sulfur in quantities as little as 0.5 pound per 100 square feet of bench area prevented the chlorosis and overcame the tendency of the sodium and calcium of the nitrates used to induce the deficiency. Chlorotic blueberry plants at the same station were restored to normal foliage color by injection of an iron compound into the plants. The more practical measure of applying either ammonium sulfate or aluminum sulfate to the soil also relieved the symptoms.

Weeds and volunteer grasses at the Florida station appeared capable of absorbing much larger proportions of zinc than planted land covers take up. These plants were thus able to make enough of the soil zinc supply available to corn to prevent the white bud disease of that crop. At the California station, corn of greater height and total dry weight was grown when small quantities of zinc salts were added to the soil. Deficiency of zinc lowered the yield of cobs and kernels

more than that of stalks, leaves, and husks. In tomato plants studied at the same station, it was found that in addition to distortion, stunting of growth, and chlorosis there were certain abnormalities in the microscopic internal structure of the leaves which served as symptoms indicating zinc deficiency.

Copper-deficiency symptoms have been similarly studied at the California station, which has traced the abnormal condition of Bartlett pears known as exanthema to a copper deficiency. Copper salts applied to the soil, crystals of copper salts placed in the root crown of the tree, and sprays of bordeaux mixture were curative measures.

A typical manganese-deficiency chlorosis has been found by the Florida station to affect many species of ornamental plants and was shown to yield to the well-known treatment of spraying manganese sulfate solution onto the foliage or adding the same salt to the soil. With the cooperation of the Department (B.P.I.), the Louisiana station has traced a crinkle-leaf disorder of the cotton plant to an association of high acidity, calcium deficiency, and manganese toxicity due to excess of soluble manganese compounds in the soil.

Of deficiencies in the nonmetallic trace-requirement elements, that of boron has been most conspicuous in the past year's work. At the New York (Cornell) station, internal break-down of table beets was greatly reduced by borax treatment of the soil, fewer beets being affected and the injury to those affected only slight on the soils treated with this source of boron. At the Wisconsin station, soil treatment with borax prevented certain disorders which had been observed in garden and sugar beets and in cabbage. Borax, either broadcast or applied in bands near the rows with the fertilizer, also corrected internal black spot of canning beets at the Wisconsin station. Internal black spot was shown to have much in common with the boron-deficiency disease now known as heart rot. No pathogenic organism was involved as a primary cause of the trouble. It was prevalent under a variety of soil conditions, but most of the soils were alkaline. At the Idaho station drought spot of prunes and apples and corky core of apples were found not only to be more prevalent in years of inadequate moisture supply but also to occur more often in certain localities and to be associated with a low boron content in the fruit tissue. A definite correlation between these diseases and the occurrence of low boron content in the fruit and pit of prunes was indicated. At the Maine station a greenhouse method for detecting boron-deficient soils has been devised that has given good correlations between greenhouse and field results. Fall applications of from 40 to 60 pounds of borax per acre were shown to be more effective in preventing the yellowing of alfalfa than were spring applications. Preliminary investigations indicated a higher boron content in normal than in yellowed alfalfa. At the Oregon station, canker of table beets, which sometimes causes loss of all the marketable crop, was not improved under treatment with potassic fertilizers and was even increased by lime or by large applications of potassic fertilizers, but this condition was prevented by as little as 10 pounds per acre of boric acid, a treatment which also gave striking increases in yield. At the same station, the incidence of stem crack of celery was reduced from a range of from 32 to 50 percent in untreated rows to a range of from 0 to 9.5 percent in

rows treated with borax at the rate of 20 pounds per acre. The boron compounds used to correct plant malnutrition at this station doubled the boron content of the plants, slightly affected their protein content, and increased their chlorophyll content by 50 percent.

In an Akin soil at the Oregon station an iodine deficiency was indicated by a 37-percent increase in red clover following application of potassium iodide at the rate of 4 pounds per acre.

For *Citrus* species, the preparation of a colored photographic record of symptoms of mineral-element excesses and deficiencies has been begun at the California station. Studies both of the gross and of the microscopic histology of bitter pit of apples at the New York (Cornell) station, of Kelsey spot of plums at the New Jersey station, of black end of pears at the California station, and of granulated orange vesicles at the California Citrus station have also been reported upon. Knowledge of the symptoms thus studied may be expected to aid in identifying the excess or deficiency needing correction.

Soil selenium, toxic to many plants and dangerously poisonous to most animals consuming plants or water containing compounds of this element, has been studied at the South Dakota station. Selenium was found in most of the rocks of South Dakota, but the element occurred usually in very small quantities. Only in certain formations, or beds within these formations, was highly seleniferous rock found to be so exposed as to cause poisoning to livestock by the production of a seleniferous vegetation. The Niobrara formation, of which the outcrop covers but a very small area in the State, and the lower Sharon Springs member of the Pierre formation were the most highly seleniferous materials found, the last-named being a rock so resistant to weathering as to form little soil capable of bearing vegetation. "Converter" plants, capable of taking up selenium not available to other plant species and then leaving it in the soil in a form in which it can be absorbed by species unable to extract it directly from the original soil supply, were found to play an important part in the development of selenium toxicity in crop and forage plants.

Arsenic compounds were fixed in soils studied at the Washington station more readily when in the form of arsenates than in that of arsenites. At the California station, arsenic toxicity was greatest in sandy soils, least in soils of high clay content. All red soils, regardless of texture, rendered much arsenic nontoxic.

Chlorate toxicity in soils, like arsenic toxicity, was, in general, greater in the soils of coarser texture in trials at the California station involving repeated cropping.

ORGANIC MATTER AND NITROGEN

At the New Hampshire station a large annual loss of fertilizer value, estimated, for the State of New Hampshire alone, at about \$800,000, has been shown to result from inadequate protection of stable manures against leaching and loss of free ammonia. This station has proposed prevention of this loss (one-half of which is equal in value to the plant food annually bought in the State) by means of sheds to stop the leaching and the addition of superphosphate to hold the free am-

monia, together with careful choice of time of spreading and the practice of harrowing the manure into the soil immediately after spreading. At the Ohio station, on the basis of economic considerations, it has been found preferable to depend on storage in a moist, compact condition, together with prompt covering with soil after spreading in calm, cool, moist weather, rather than to use chemicals to hold the ammonia. Acid peat moss, however, because of its absorption of ammonia and its tendency to limit fermentation, has been recommended by this station for use, when available, as a stable litter which will permit less loss than is usually met with when straw is used. At the Nebraska station farm manures were found to have a high residual value. Good yields have been maintained for 25 years of a 6-year rotation in which 12 tons per acre of manure were applied once in each complete cycle of the rotation. In the North Platte Valley of Nebraska, where these rotation experiments were carried out, increases in livestock population of from 90 percent for a 6-year rotation to 370 percent for 2-year rotations would be necessary, however, for maintenance of the fertility of the soil, according to the results of this work.

In a study of green-manuring materials at the Massachusetts station it was found that the average percentage of nitrogen was greater in dicotyledonous than in monocotyledonous plants, and the percentage of components resistant to decomposition in the soil was less in dicotyledonous than in monocotyledonous plants. Decomposition of plant residues in the soil, as indicated by ammonia and nitrate formation and by crop growth, increased with decreasing carbon:nitrogen ratio. When the carbon content was not more than from 25 to 30 times the nitrogen content the residues decomposed readily in the soil, but at higher ratios of carbon to nitrogen the soil nitrate content was lowered by the decomposition. Various components of the soil organic matter in plats of arid soils under continuous fallow, oats, and alfalfa have been studied at the Utah station. The protein fraction, the part of the organic matter more readily decomposed with nitrification, decreased with increasing depth in the fallow and oats plats but increased with depth in the alfalfa plat. The lignin-humus fraction, or more permanent components of the organic matter, increased with depth in the fallow plat but decreased with depth in both the oats and alfalfa plats. Cotton burs, plowed or disked into the soil at the Oklahoma station, produced an increase in the yield of seed cotton about twice as great as that given by the ash from an equal quantity of the burs. The value of numerous green-manuring crops, in terms of the cost of corresponding quantities of nitrogen, phosphate, and potassium obtained in the forms of ammonium sulfate, treble superphosphate, and the fertilizer grade of potassium chloride, at the respective current prices of these chemicals, has been studied at the Colorado station. In a comparison, at the New Jersey station, of land cultivated for 30 years with land abandoned to grass and weeds for the same period, it has been found that, without exception, the soil of the uncultivated area contained more of both carbon and nitrogen than was found in the cultivated land. The base-exchange capacity of the uncultivated soil was greater than that of the cultivated, a condition attributed in part to the exchange capacity of the accumu-

lated organic matter. At the Kansas station, continuously grown alfalfa increased the soil nitrogen and carbon contents by 0.71 and 0.43 percent per year, respectively, continued to increase the soil nitrogen content throughout 19 years, and increased the soil nitrogen content even when all top growth was regularly removed as hay. In general, manures and green-manure treatments held the soil nitrogen and carbon at percentages higher than those found in the control plats. Commercial fertilizers produced similar, but less marked, effects. Accumulation in the soil of carbon dioxide, one of the products of all organic-matter decomposition in the soil, decreased the rate of decomposition in an investigation reported from the Iowa station. Adding a water solution of carbon dioxide stimulated nitrification but treatment with the gas itself had no significant effect of this sort. The stimulation effected appeared to be due to increase in the solubility of mineral constituents of the soil needed by the nitrifying organisms. *Crotalaria* and velvetbeans, used at the Florida station as green-manure crops, both increased the weight of lemon seedlings to between 2 and 3 times that of the plants grown in untreated soils.

SOIL MICROBIOLOGY

Certain soils investigated at the New York State station partly lost their ability to support the growth of test micro-organisms by merely being allowed to become air-dry. The air-dried soils could, however, be restored to normal bacteria-producing power by holding them at 35 percent of their water-holding capacity for about 2 weeks before adding the bacterial nutrients, sterilizing, and inoculating. There was some indication that potassium fixation may have been involved. The importance of knowing and making allowance for this fact in using soil bacteria as indicators of plant-nutrient deficiencies is evident.

At the Utah station, adding ground alfalfa, pea vines, or straw to a dry-farm soil increased the nitrogen-fixing power, the effect of the alfalfa persisting longer than that of either the pea vines or the straw. At the Iowa station a prolonged growth of *Azotobacter* in Clinton and Grundy silt loams required an addition of lime sufficient to reduce the soil acidity nearly to neutrality, but no other treatment or added nutrient was necessary. Treatments other than the liming, with the exception of the addition of oat straw, brought about no increase in growth. At the Washington station, organic residues of higher base content, when added to soils of but slightly acid reaction, stimulated bacterial growth more than did those of lower base content. Differences in the vegetation, by causing differences in the quantity and nature of the organic residues added to the soil, are, therefore, considered to play an important part in the development of specific inherent soil properties, especially humus content, reaction, color, and physical structure. At the New Jersey station, thermophilic organisms (organisms growing best at temperatures high enough to kill or inhibit micro-organisms of many ordinary types) were found in variously treated field soils. The most rapid initial decomposition of manures was found to be due to thermophilic organisms, the process beginning most rapidly at 65° C. (149° F.),

after which a more rapid further decomposition took place at 50° C. (122° F.), while at 28° C. (82.4° F.) active decomposition began only slowly, becoming rapid after 9 or 10 days. The nitrogen was conserved only when the decomposition began rapidly. Composts of plant residues were produced rapidly by thermophilic organisms, especially when calcium carbonate had been added, at a temperature of 50° C., a mixture of 80 percent of straw with 20 percent of alfalfa requiring no added mineral nutrients. Cereal straw alone, with mineral nutrients and calcium carbonate, yielded an excellent compost in from 3 to 5 weeks. The common edible mushroom grew well on such composts.

All of the salts contained in natural "alkali" soils and in an artificially salinized soil, at the Oregon station, depressed the rate of decomposition both of the native soil organic matter and of added straw. Sodium chloride had the greatest effect and sodium sulfate the least, with magnesium sulfate and sodium carbonate intermediate in their effects. Sulfur oxidation was not influenced by sodium chloride or sodium carbonate. Sulfur oxidation decomposed 70 percent of the sodium carbonate completely with formation of carbon dioxide, the remainder being converted into bicarbonate.

SOIL MOISTURE AND WATER MOVEMENT

The capillary conductivity of peat soils, studied at the New York (Cornell) station, was found to be very low in the presence of relatively high moisture contents. At the same station, lack of moisture in orchard soils has been shown seldom to limit productivity in New York orchards on well-drained soils of relatively high permeability and of a rooting depth of as much as 4 feet. Poor permeability and drainage, however, together with bedrock at a shallow depth, were found capable of causing inadequate moisture supply. In an orchard plot having soil only 2 feet deep, a lack of rain for 2 weeks in a season of about normal total rainfall reduced the soil moisture to the permanent wilting percentage. At the Michigan station a high percentage of organic matter has been shown to increase markedly the available water capacity of light soils. To a lesser degree a relatively large proportion of organic matter had a similar effect upon heavier soils. Added organic matter also increased the percentage of moisture held by the soil at the wilting point, but the percentage of this nonavailable water rose less rapidly in proportion to the percentage of organic matter than did the retention of water available to plants. A cooperative investigation by the Montana, North Dakota, Nebraska, and Kansas stations and the Department (B.P.I.) has shown that the zone of normal wheat-root development is usually dry at harvest. Accumulation of moisture takes place, however, loss through weeds being prevented, from harvest until the spring crop reaches the stage of a transpiration rate exceeding the precipitation supply. This cycle was found generally to be confined to the zone of free root development, no water reaching the subsoil. Available water was removed to a greater depth under sod than under continuous grain. The subsoil was found generally to be less dry under continuous grain production than under sod. At the Wyoming station, a light fine sandy loam soil was shown to have

retained only 5 percent of moisture at the point at which crop plants could extract no more water from it, whereas a heavier soil (a loam) still held from 13 to 15 percent of moisture at the "permanent wilting point." At the Illinois station infiltration capacities have been measured at 14 locations. Of these locations 3 showed high infiltration capacity and 11 a low capacity. The factor dominant in causing variations in capacity for infiltration of water appeared, in this work, to be that of the physical character and condition of the soils themselves. Evaporation losses in normal forest, in open park, and in cleared areas have been recorded at the Ohio station. Data believed to represent evaporation from all causes other than sunshine indicated a loss of 77 percent as much moisture in open-park areas and 46 percent as much in normal forest areas as in the cleared areas.

At the Nebraska station the mathematical procedure necessary for calculating the weight of water in a soil or subsoil mass in which the moisture content increases with distance from a plant or group of plants has been worked out and the result reduced to a formula, the practical application of which involves only simple arithmetic. At or above the wilting point the soil-moisture film is thick enough to cause coherence of soil particles when lightly pressed together, whereas such cohesion will not take place below the wilting point. On this principle a mechanical method for determining the permanent wilting point of soils has been devised at the Michigan station. This station has also designed and made a portable field outfit for determining soil-moisture content by the method of adding alcohol to the weighed sample and burning off the alcohol.

SOIL CONSERVATION AND LAND USE

Restoration of normal productivity and tilth of more than 4,000 acres of lands covered by field silt deposits has been studied by the Vermont station. These deposits, left by rivers carrying from 7 to 19 inches of rainfall, were from 1 to 6 inches deep, and in more than one-third of the area involved they were too deep to be plowed under. Most of the deposits lacked plant food other than lime, and some of them lacked lime also. Manures applied at the rate of from 10 to 20 tons per acre or from 200 to 400 pounds per acre of double-strength commercial fertilizer produced good crops. Small subsequent applications were found to be preferable to larger additions made once in a rotation. Early spring seeding, especially of legumes, was found vitally necessary. Surface sowing before machinery could be used gave good results with sweetclover, a crop which produced a large tonnage and improved soil condition. Bromegrass was shown to be the best sod-forming grass for dry silts. On shallow neutral deposits mixed oats, red and alsike clovers, timothy, and bromegrass did well. On deep deposits, if heavily manured, corn, rye, barley, and buckwheat were successful. Shallow acid deposits could be plowed under and planted to the same crops that were found profitable before the alluviation. To check the blowing of sandy deposits was shown to be more important than to improve their fertility. They were best plowed under when the old soil could be reached, since harrowing

increased the blowing. A corrugated roller was useful for checking driven sand. Quackgrass and weeds were found to restrain the blowing of sand from areas not yet reclaimed onto adjacent lands.

Erosion-control investigations are being undertaken at an increasing number of stations. Willows planted along riverbanks have been shown by the Vermont station to help in preventing further cutting away of croplands. The Connecticut State station has cooperated in the Department erosion work on the Scantic River watershed. A study at the New York State station of results of a single heavy rainfall (4.5 inches in 12 hours; maximum intensity, 6 inches per hour) has given a striking illustration of the possibilities of soil loss in a section not generally thought of as having readily erodible soils. A fallow plot of Dunkirk soil on a slope of about 5 percent lost 66 percent of the total rainfall as run-off, with which 46 tons per acre of topsoil were removed. A fallow plot of an Ontario soil, somewhat more permeable than the Dunkirk but on a steeper slope, lost 52 percent of the total rainfall with 24 tons per acre of the topsoil. A similar plot of the Ontario soil on which a green-manure crop of rye had been plowed under lost 42 percent of the rainfall and 13.5 tons per acre of soil. Corn in rows across the slope of the Dunkirk soil reduced the loss to 28 percent of the rainfall and 8 tons per acre of the soil. A red clover plot lost but 5.5 percent of the rainfall, with only 89 pounds per acre of soil. Soybeans and grass lost less than 1 percent of the rainfall, and but 30 and 10 pounds, respectively, of soil per acre. This station has found that "moderate slopes may be cultivated safely if recognized soil erosion control measures are practiced" and has set forth 11 practicable measures of protection and remedy upon which such cultivation should be based. The value of phosphates in encouraging the development of a bulky root system is emphasized, together with the practice of leaving grass in the waterways of sloping lands. At the Pennsylvania station an analysis of strip-cropping practices on 19 farms on which strip cropping has been in use for from 5 to 20 years has been carried out with the cooperation of the Department (S.C.S. and B.A.E.). Strip cropping was said by 9 of the farmers to have been started without outside knowledge or influence, 5 had the idea from neighbors, 3 from reading. Degree of slope was generally the deciding factor in determining the need for strip cropping, and degree of slope, together with convenience in field size, was the most important factor in determining width of strips. The average width on the farms surveyed was 139 feet; the average slope, 16.4 percent. Strips averaged 4 percent off actual contour. A tendency toward less clean tilled crops on the steeper slopes was observed. There were sod waterways on 9 of the 19 farms, but they were fully adequate for erosion control on 3 farms only. In general, the operators of the farms studied thought the strip-cropping system used to have saved time and power and to have increased yields as compared with those of from 10 to 15 years ago. Erosion has been markedly reduced at the Texas station by alternate strip cropping of cotton with oats as compared with cotton in rows down the slope or with cotton alone on the contour. This work led to the conclusion that where terracing is

also needed, strip cropping will furnish protection until it becomes possible to terrace the land. Average annual inches of water and tons of soil lost during 11 years from lands having slopes of from 0 to 3 percent have been tabulated at this station.

On an area of De Kalb soil classified as submarginal and abandoned for 40 years, the Pennsylvania station has shown that this type of farm land is capable of profitable production under a system including the regular use of lime, commercial fertilizers, and manure. Yields were raised from a weighted crop index of 76.6 (on the basis of the State average taken as 100) to a crop-producing value of 113. On peat lands studied at the Wisconsin station, potassium salts have been shown to be the principal fertilizer requirement, 300 pounds per acre of a fertilizer of 50-percent potash content having been used to maintain production in a 4-year rotation. In the glacial drift area these peat lands needed no lime. West of this area some lime requirement was found. Phosphates caused a lodging of grain, but phosphate applications equivalent to 80 pounds per acre of phosphoric anhydride (P_2O_5 , often spoken of as phosphoric acid) applied once in each 4-year rotation benefited several other crops. No consistent need for nitrogenous fertilizers could be shown. Row application of the fertilizers was generally the most profitable. The crop adaptations of these lands were studied in some detail.

The Connecticut (State) station, showing the need for surveys and maps designed especially for land use planning and of a type radically different from those required by the taxonomic soil survey, has pointed out that—

two soils of distinct series, alike in textural class and topographic features, frequently present more similar crop-production problems than different degrees of texture within the same soil series.

Further—

several generations of farmers on the soils of most of the United States east of the Great Plains have modified these soils to the extent that many naturally low-grade soils have been built up to high levels of productivity, and perhaps greater areas have been depleted by erosion and poor farming to the point where they are not economically reclaimed.

At the Michigan station a study of soil survey maps and data has led to a similar conclusion, namely, that soil types as at present differentiated may be regarded in part as natural land types, but that the same soil type is not everywhere the same land type. Natural land type is more inclusive of the natural factors that influence the use and value of land than is soil type alone. At this station a tentative classification of swamplands into 12 patterns, based in large measure on the shape, size, and association of the separate bodies of such land, has been made; such lands forming a sufficient part of the natural landscape of the State to have some degree of importance in relation to land classification for land use planning programs. Topography, soil structure, organic-matter content, water supply, and climate have been emphasized at the Wisconsin station as of importance in the assignment of lands to specific agricultural uses. At the Colorado station crop yields in relation to precipitation records from four dry-land field stations were used as a basis for estimating probable yields on soils developed in the plains region of eastern Colorado.

Although Keith silt loam and Prowers loam were given the same productivity ratings under similar precipitation, it was readily shown that the average yield on the Keith soil was nearly three times as much as on the Prowers soils when the region in which they occur in eastern Colorado was considered and the distribution of good, fair, poor, and failure years accounted for.

From the percentage annual gain or loss of total nitrogen supply in the surface soil taken as a productivity factor and the percentage of total nitrogen and organic-matter loss by sheet erosion called the erosion factor, the Missouri station has found it possible—

to determine approximately the annual gain or loss in productivity for a field, farm, or county. These productivity indices and erosion factors provide an approximate measurement of the annual gain or loss in the productivity of the soil under the land-use or soil farm management program of the farm.

At the Maryland station a productivity classification for all the soil areas and types of the State has been prepared and published. From the Florida station a similar publication has been issued. The deteriorating effect of continual flooding and cropping of ricelands has been studied at the Louisiana station, where it was observed that leguminous organic matter effected an improvement in the broken-down structure, whereas gypsum, lime, and sulfur were much less effective.

SOIL PROFILES AND SOIL STRUCTURE, TEXTURE, AND COLOR

At the New Hampshire station difficulties in showing the profile structure of soils accurately in photographs have been overcome by a new technique of profile drawing, and some relations of profile structure to important soil properties have in this way been brought out. At the California station the mineralogical composition of the clays of two Alabama soils have been shown to be quite distinct. The effect of such differences in the mineralogical character of the clay content of soils on phosphate fixation has already been indicated in the section on mineral nutrients. Effects of irrigation and cropping on soil profile structure have been studied at the New Mexico station. In a study of clay pan soils at the Oklahoma station in cooperation with the Department (B.C. and S.), it was found that roots penetrated through the clay pan instead of following around outside of the clay pan columns. Concentration was markedly decreased in the gray layers and in the incipient gray layers immediately above the pan, an effect tentatively attributed to poor drainage of the gray horizons.

At the Connecticut (State) station, removal of the surface layer of forest soils has been shown to lessen the percentage of aggregates (the crumbiness or granularity of the soil) in the first inch of the mineral soil by about 40 percent in $3\frac{1}{2}$ years. In the next 2 inches the decrease was between 11 and 24 percent. The loss of aggregate content in the first inch of mineral soil surface reached 58 percent in $2\frac{1}{2}$ years in some instances. It has been shown by the California station that in chaparral areas of the San Gabriel Mountains certain forest types were associated with low field-moisture capacity, others with a high capacity. The depth of water retained by the forest floor represents an integration of amount, volume weight, and field-moisture capacity of the organic materials.

At the New York (Cornell) station it has been shown that organic material and calcium carbonate apparently quite sufficient to insure

good granulation may be found in soils which in actual practice are of very poor structure and are unproductive. The instances observed were sufficient to indicate that—

while lime and organic matter may favor the development of a favorable structure in heavy soils, they do not in themselves insure a good granular structure. The best structure is usually found in virgin soils or in soils that have been in sod for several years.

In experiments reported from the Missouri station, soluble calcium compounds in the soil (as distinct from calcium united to the exchange complex or present as insoluble compounds) may have a direct influence upon granulation by causing a flocculation of the particles, which may be bound together into stable aggregates as by organic matter. The exchangeable calcium content of the soil could not, therefore, be taken as an index of the stability of the granulation of the soil. Calcium compounds in the soil also appeared to help granulation indirectly through their tendency to preserve the soil organic matter. At the Kansas station soil under corn and kafir maintained a good state of aggregation, but after oats the breakdown of soil aggregates into colloid fine material was greater when oats followed sorghum than when this crop followed corn. Sweet-clover or alfalfa with sweetclover left the soil in a state of aggregation better than that found after a soybean crop. Liming further improved granulation following sweetclover or red clover. It appeared (compare the relation between liming and organic matter noted in the Missouri station work above cited) that lime with a legume crop and possibly with other crops had an effect not exerted by lime alone. Liming a fallow soil in a greenhouse experiment gave no better granulation than was found in the same soil unlimed. A method for measuring quantitatively changes in the coarser structure of soils, developed at the California station, made it possible to show that plowing decreased both cloddiness and the volume weight of the soil unless the plowing was done at an excessive moisture content. Disk and spring-tooth harrows appeared more effective than spike-tooth harrows for reducing cloddiness. Rolling and leveling increased the volume weight and had a pulverizing effect on dry soils, but moderately moist soils usually showed increased cloddiness after these operations. The cloddiness of soils worked to a highly pulverized condition was greatly increased by irrigation, often becoming much greater than that observed before any tillage. Tilled areas left cloddy were less affected by irrigation.

Soil color and its measurement have been studied at the California station to establish definite standards, avoiding the present confusion of indefinite color terms. At the Nebraska station, where soil pigmentation was studied in relation to humus content, temperature, and precipitation, the soils of darkest color were found to be not necessarily those of highest organic content. Humus color in the soil extract was proportional to the relative pigmentation of the soil, however. In regions of approximately equal rainfall, pigmentation and humus content were more or less definitely related to mean annual temperature. In general, for every fall of 10° C. in the mean annual temperature, precipitation remaining the same, the organic matter and humus content were found to be approximately doubled, and the relative pigmentation of the soil was increased from

two to six times. At the Oklahoma station, the color in Randall clay and in an adjacent upland soil, both being fine-textured soils formed on lacustrine deposits, has been shown to be related more closely with the character of organic matter present than with the total quantity of organic matter, nitrogen content, minerals in the parent material, or the texture of the soil.

PLANT DISEASES AND INSECT PESTS

CONTENTS

	Page		Page
Introduction.....	81	Truck-crop insects.....	103
Grain diseases.....	81	Orchard diseases.....	106
Grain insects.....	85	Orchard insects.....	110
Cotton diseases.....	85	Small-fruit diseases.....	114
Cotton insects.....	86	Small-fruit insects.....	116
Tobacco diseases.....	86	Ornamental-plant diseases.....	116
Tobacco insects.....	88	Ornamental-plant insects.....	119
Sugar-plant diseases.....	89	Tree diseases.....	119
Sugar-plant insects.....	90	Tree insects.....	121
Forage and cover-crop diseases.....	90	Miscellaneous diseases.....	122
Forage and cover-crop insects.....	92	Miscellaneous insects.....	123
Potato and sweetpotato diseases.....	93	Biological control.....	125
Potato and sweetpotato insects.....	95	Fungicides.....	126
Truck-crop diseases.....	96	Insecticides.....	128

INTRODUCTION

With the determination to find more effective, safer, and more economical means of defending American agriculture against the constant inroads of plant pests and diseases, the experiment stations are directing the resources of science and the resourcefulness of well trained staffs energetically toward this end. The fact must be faced that modern cropping practices, although highly successful in other respects, often interfere seriously with the common agencies for pest control provided by nature and encourage the spread and intensification of damage due to insects, fungi, bacteria, viruses, and nematodes. Relief can come only as effective methods of suppression are developed by research and put into operation on the farm. That scientific investigation in this direction is making constant progress is evident from the results reported from all States. For lack of space only selected examples can be given to show something of the scope of work going forward and the type of results expected. The items presented by no means disclose the full range of endeavor in any field or at any station. They merely illustrate in a typical way how stations are using their Federal-grant funds to work out crop-pest problems.

GRAIN DISEASES

Station and Department (B.P.I.) research on cereal diseases and the work of testing for disease resistance have been largely and effectively coordinated in a national cereal program through long-continued Federal-State cooperation. Individual references to such cooperation are omitted for brevity. General use of chemical seed treatment has already greatly reduced annual losses from bunt or stinking smut. Experimental work is being continued, however, in

order to determine the value of newer treating materials and particularly to develop bunt-resistant wheats suitable to all parts of the country so as to render seed treatment eventually unnecessary. The Nebraska station reported that of various fungicides tested for from 3 to 8 years each, copper carbonate and New Improved Ceresan dusts proved most practical and were highly effective without injury such as is sometimes occasioned by formaldehyde. Complete suppression of bunt apparently required treatment for 2 successive years with occasional later repetitions, but treatment without removing the bunted kernels did not eliminate the disease. The Oregon station, with the Department (B.P.I.), also reported the superiority of New Improved Ceresan for the seed and the equality of copper carbonate and copper sulfate in reducing infection through soil. The Washington station, with similar cooperation, worked out for the benefit of wheat breeders the method of inheritance of the resistance of various wheat types and crosses to different biological races of bunt. At the Washington and Idaho stations a very useful method of inoculating seedlings was developed for use in testing the susceptibility of individual lines of wheat to individual strains of bunt.

No wheat disease has caused more sweeping damage in epidemic years than stem rust. The Kansas station has reported on the conditions responsible for the epidemic of 1937. The magnitude of the losses and the comparative extent of attack on the principal commercial varieties were estimated. The Colorado station reported on work with the Department (B.P.I. and B.E. and P.Q.) resulting in material reduction of damage from stem rust within the State due to barberry eradication, early planting of spring wheat, and the use of rust-resistant varieties. Texas station tests showed that early Blackhull wheat is highly resistant to 10 physiologic races of stem rust prevalent in Texas. Over a thousand samples of this rust from all over the country in 1938 were analyzed at the Minnesota station. Physiologic race 56 was found in over 80 percent. Resistance to race 56 as well as to most others is the chief reason why the Minnesota station variety Thatcher, by replacing Ceres and other susceptible kinds on thousands of farms in 1938, resulted in a saving of some 33,000,000 bushels of wheat that would otherwise have been destroyed that year by the rust epidemic in the Red River Valley. This station also contributed new knowledge as to the conditions of temperature, light, and humidity that determine what races of rust will develop actively in any season and locality and what wheat varieties may be expected to survive. At the Texas station a puzzling mystery was solved when it was found that a brown head discoloration mistaken for the bacterial black chaff disease was only a manifestation of defeated rust infection in certain resistant wheats. Chemical control of rusts on especially valuable crops may prove practicable through the use of toluene sulfonylamide or certain other chemicals which the Minnesota station has found effective on cereals though too expensive for general field use.

Leaf rust of wheat is even more destructive than stem rust in the more southerly regions. The existence of not less than 105 different physiologic races was demonstrated at the Indiana station. The Oklahoma station found this disease largely responsible for the loss of 25 to 30 percent in wheat yield and quality in that State in 1938.

Fortunately there has been breeding for resistance. In Indiana Chinese wheat was crossed with emmer, rye, and a wild-rye species and the progeny, in certain instances, showed a degree of resistance that may prove useful.

Most encouraging is the promise of success attending efforts by the various State stations and the Department to combine, in superior varieties of grain, resistance to several types of destructive diseases and pests. At the Washington station 458 strains of spring wheat were tested under greenhouse epidemic conditions and more than 50 found immune or highly resistant to local strains of powdery mildew, stem rust, and leaf rust, while many were also resistant to one or more races of bunt. Practical proof of the value of breeding for resistance is found in Texas, where the station reported high yields of wheat and oats free from leaf rust and stem rust in sections of Texas where, because of these diseases, these grains could not be grown commercially before. The Minnesota station announced 3 back-crosses of Thatcher \times Hope wheat that are proving highly resistant to leaf rust as well as stem rust. Furthermore, some 150 oat hybrids that appear resistant to stem rust, crown rust, and the smuts were ready for performance tests in different parts of the State. The South Dakota station found many reselections from wheat variety crosses (Hope \times Ceres and Hope-Reliance \times Reward) resistant to both stem rust and leaf rust and worthy of testing for final selection. The Wisconsin station found Chevron barley, a spring type, resistant to stem rust through a single genetic factor and also resistant to scab, powdery mildew, and the stripe disease, any one of which under favorable conditions may ruin a crop. It is susceptible, however, to leaf rust and to certain smuts. Hence an effort is in order to develop resistance to these troubles. At the Iowa station tests of some 5,000 selections from crosses between rust-resistant and smut-resistant types of oats have yielded exceptional promising strains some of which combine superior yields with resistance to not less than 4 different disease-producing fungi. Outstanding are selections from Markton \times Rainbow and Markton \times Iogold. For testing the resistance of oats to smut in such work, a method was developed at the Idaho station of immersing the seed in a smut suspension which is both more rapid and better than dehulling and dusting with smut. At the Arkansas station it was discovered that Bond oats and its hybrids which were very susceptible to race 45 of crown rust in the greenhouse were not noticeably attacked by this race in the field during the severe epidemic of 1938 and would thus appear worthy of retention in the resistance breeding program. On the other hand, Black Mesdag, a variety widely used as a smut-resistant parent in oat breeding, may have to be discarded for this purpose since at the Minnesota station it was found attacked by certain loose smut strains from Oklahoma and Kansas. The stem nematode has now begun to cause trouble in oats on the Pacific coast, as it has long done in Europe. Search was made by the California station for resistance. Of 130 varieties tested, Victoria, Capa, and Pampa showed no evidence of attack in an infested test field while 14 percent showed good resistance.

Many seed-borne and soil-borne diseases of cereals, as reported before from many stations, have been found controllable to some ex-

tent by chemical treatments. Even in the case of the air-borne rust and leaf diseases of small grains considerable increase in yield of wheat, oats, and barley was reported by the New York (Cornell) station from the use of sulfur dust on an experimental basis. The Colorado station reported increased corn stands from dusting seed with organic mercury. The Iowa station made the interesting discovery that one such material, ethyl mercury phosphate, may be so used as to induce in corn and sorghum the inheritable change, much sought by plant breeders, known as polyploidy.

Contributing to the study of seed- and soil-infesting cereal diseases, the Kansas station showed that the reason crop rotation is valuable in reducing attacks of take-all may be due to the fact that carry-over into the next season is confined mainly to the infected roots of living plants. The Oregon station uncovered evidence that at least five different fungi may attack the roots of small grains in the Pacific coastal strip where many varieties have been unproductive. The Illinois station found two soil fungi (*Aspergilli*) interfering with the development of normal green color in corn seedlings, and the Iowa station disclosed a further cause for low yields when it reported the fungus *Basisporium* as prevalent in arrested corn shoots and secondary ears. The Wisconsin and Minnesota stations contributed information and techniques useful in further research on the destructive *Diplodia* cornstalk and ear rot and on the biotypes of the corn smut fungus, respectively. The Kentucky station showed that one of the blue molds (*Penicillium oxalicum*), is a soil-borne seedling destroyer for corn while other blue molds were noninjurious or may even protect corn kernels from infection by it.

The Iowa station helped lay a basis for eventual improvement in the sanitary condition of agricultural seed through a long study of methods of detecting and identifying disease-producing organisms carried in different lots of seed of barley, corn, flax, oats, and wheat, and on the response to seed disinfectants. Extensive studies of similar nature are needed before American agriculture can benefit fully from the Nation-wide seed-testing services already established.

A difficult problem is that of utilizing advantageously disease-damaged crops which cannot be disposed of through the usual channels. The Illinois station, in studies extending over some years, proved that *Gibberella*-infested corn was poisonous to the animals used in feeding tests while corn infested with *Diplodia*, and that infested with *Fusarium* to an even greater extent are distinctly inferior in protein and energy value to sound corn from the same crop.

Studies on rice diseases at the Crowley, La., rice station, threw light on the trouble called pecky rice which proved to be due largely to a *Helminthosporium* fungus, and disclosed a new leaf blotch with a nonsporulating fungus. The Arkansas station noted the tendency of potassium in the fertilizer either alone or in combination with nitrogen and phosphorus to retard the development of rice stem rot, while the Texas station found that the black-kernel disease of rice is caused by a fungus (*Curvularia lunata*) which infects during flowering, a fact important in working out preventive measures.

Success in developing desirable wilt-resistant types of flax adapted to the State seemed assured to the Minnesota station by the preliminary tests in three localities with crosses of the Bison and Redwing

varieties. The problem is more difficult in the case of flax root rot and damping-off which may be due to a number of fungi, and the difficulty is increased by the existence of diverse races so that, in breeding for resistance, either varietal tests must be conducted in many places to get exposure to all the prevailing races or the latter must be combined in the soil at the station breeding plats.

GRAIN INSECTS

The annual wheatfield insect survey for 1938, by the Ohio station, showed the value of the safe sowing dates worked out by the station for preventing serious hessian fly damage. As a guide to crop planning the Illinois station and the Department (B.E. and P.Q.) co-operated in a 4-year study which showed the degrees to which chinch bugs were attracted to different kinds of small grains early in the season. Oats proved the least attractive throughout, though not escaping entirely. No small grain showed promise of usefulness as a trap or concentration crop. Continued studies by the Louisiana station on methods of preventing damage from insects in milled rice demonstrated that small three-ply bags, taped shut, and paper bags with metal strips to cover the stitches and close the tops, successfully excluded insects which enter through stitching perforations in ordinary sacks.

COTTON DISEASES

Much of the research on cotton diseases has recently been conducted on the basis of formal or informal cooperation between the workers in the different cotton-growing States and in the Department (B.P.I.) facilitated by the annual conference of the Cotton Disease Council, established in 1936. The effectiveness of coordination by voluntary agreement is evidenced by the rapid progress made toward the control of a number of destructive cotton disorders which add greatly to the cost of producing a bale of cotton.

The Arkansas station and the Department, cooperating in studies on the widespread *Fusarium* wilt of cotton, found that cotton varieties having various orders of resistance to one biological strain of the wilt fungus showed the same relative resistance to all other strains tested regardless of differences in their virulence. This greatly simplifies the breeding of wilt-resistant cotton varieties. The Arkansas station also demonstrated that soil moisture, temperature, and acidity must be taken into consideration in any resistance or control tests.

The Texas station has worked for many years with the Department (B.P.I.) in an effort to find chemical substances that may effectively hold root rot, the most destructive of all cotton diseases, in check. Alkaloids were extracted from kinds of plants known to withstand the disease. Certain of these alkaloids at high dilutions were markedly poisonous to the fungus in culture. Among a series of metallic elements also tested, copper, cobalt, and nickel were found most highly toxic to the fungus. In Houston black clay soil the root rot pathogen could grow with moisture between 8 and 35 percent, doing best at a temperature of about 80° F. It died at 102° and failed to grow at 37° though remaining alive. Therefore, rapid spread and field damage is favored by intermittent rains and warm

but not too hot weather. In controlling the disease in the Texas Blackland section the station showed that chief reliance at present must be placed on the further development of immune crops, including those fed to stock, to be used in rotation with cotton, and on the employment of sorghum barriers 30 or more feet wide to prevent spread from infested areas.

In work on other diseases of cotton, the life history of a virulent strain of the fungus *Rhizoctonia* damaging to young cotton was worked out by the South Carolina station with the Department (B.P.I.) and *Glomerella gossypii*, the cause of anthracnose and widespread seedling blight, was found to have many variant strains, the slow-growing ones being low in virulence. The North Carolina station, investigating the nature of spots and stains in cotton fibers, including blue stain, found that the fungus *Alternaria* is able to cause such troubles. Immature fibers were found most subject to infection, which occurred during and soon after boll opening, and reduction of damage was held possible by picking soon after the bolls open and storing under dry conditions. The Oklahoma station reported a water-suspension, gravity-grading system for sorting out infested and weak cottonseed from normal and healthy seeds after delinting. The New Mexico station, with the Department (B.P.I.), found that seed treated with red copper oxide gave significantly higher yields than untreated seed while Ceresan slightly delayed germination.

COTTON INSECTS

The Texas station with the Department (B.E. and P.Q.) has continued work on cotton flea hopper control. Finely ground conditioned sulfur as well as sulfur-arsenical mixtures held the insects in check under conditions of light to medium infestation. Trapping showed that the adults occurred in fairly large numbers from 21 to 26 feet above the ground while airplane collections indicated that they may reach 2,000 feet. The insect was capable of traveling at least 20 miles into cotton from areas containing the weed host *Croton*. A study of 346 balloons recovered from 3,334 releases showed drift covering 42 miles while the prevailing wind in south-central Texas was found to blow north and northeast. Flea hoppers may therefore transfer long distances from spring host plants in the lighter soil areas to cotton in the heavy soil areas, thus producing injurious infestation. The same station found that to control cotton bollworm, at least 8 pounds of calcium arsenate per acre should be applied within a week after the eggs hatch, preferably by a machine with one nozzle per row. The Arkansas station reported on a problem created by severe local damage in river bottoms due to egg deposition in the stems of cotton and corn by a species of cicada.

TOBACCO DISEASES

That there need never be a repetition of the total tobacco-seedling bed destruction sustained by many growers during epidemics of blue mold (downy mildew) throughout the main tobacco area in the past is indicated by the successful use in the past season of fumigation methods worked out by experiment stations in the tobacco-growing States and by the Bureau of Plant Industry, which is cooperating

with a number of these States. Benzol and paradichlorobenzol can be used with complete protection under special management conditions based on extensive scientific investigations.

The Virginia station with Duke University determined the influence of temperature, time, method of application, and concentration of vapors on the effectiveness and safety of paradichlorobenzene after conducting similar work with benzol. Representatives of the North Carolina, South Carolina, and Virginia stations and extension services and Duke University prepared a joint bulletin on tobacco downy mildew and its control which was published in Tennessee and Kentucky as well. The Georgia Coastal Plain station and the stations in North Carolina, South Carolina, and Maryland cooperated with the Department (B.P.I.) in extensive experiments on the control of the same disease by spraying methods, cuprous oxide with emulsified cottonseed oil giving best results as in previous tests. The North Carolina and Virginia stations investigated together the conditions that produce occasional field outbreaks of downy mildew and described the field symptoms, which differ from those usual in the seedling beds. The Connecticut (State) station reported successful control of the disease by the fumigation methods already referred to, while the Florida station found that the spray and the vapor treatments each appear to have certain advantages over the other.

The virus-induced mosaic of tobacco constitutes a serious source of low yields and quality varying with season and locality. One of the chief sources of early infection is virus contamination of the hands of field workers from smoking or chewing tobacco. The Virginia station demonstrated that although flue-curing temperatures may at times reach a point where the infecting power of the virus is destroyed, such temperatures were never reached in all parts of the barns investigated, and in some cases not in any part, so that flue-cured tobacco without further heat treatment must always be considered a potential source of infection danger. The Wisconsin station with the Department (B.P.I.) proved that two common soil organisms have the power to produce a substance which when added to a mosaic-virus solution immediately destroys its power to produce disease. Intensive study is being made on the nature of viruses, their properties, how they multiply and move within the host plants, how they produce their effects, how new virus strains arise, and how they are transmitted, the Missouri, New York (Cornell), Utah, and Kentucky stations publishing information along these lines that may lead to more effective defense against them. The latter station, using the drug colchicine, produced a new hybrid tobacco combination between White burley and *Nicotiana glutinosa* for use in breeding for mosaic resistance. The station has already combined the resistance of *Ambalema* tobacco and that from *N. glutinosa* in several burley strains. Furthermore, out of nearly 1,000 inoculated plants grown from 21 burley selections carrying *Ambalema* factors, nearly 80 percent remained free from mosaic, and when cured were indistinguishable in quality from Standard burley varieties. Similar results are being obtained in the dark-fired types.

The Pennsylvania station has shown that fermentive action in tobacco curing is associated with the rapid multiplication of certain types of micro-organisms which are being studied with a view to a

better understanding of the curing process. This station has also been actively investigating the two species of bacteria that cause disastrous epidemics of wildfire and blackfire. Either was able to produce in the laboratory typical, zonate, blackfire spots under moisture conditions like those produced by heavy fogs or dews in the field. Perhaps explanation of the baffling suddenness of widespread local outbreaks may emerge from the station's discovery that bacteria of the wildfire type, in various stages of virulence, may be found on healthy tobacco leaves while organisms of the same type, except for the capsular envelope, were obtained readily from soil and from other kinds of plants, suggesting the possibility that pathogenicity may perhaps be acquired by certain harmless bacteria under conditions affecting the physiology of both the host plants and bacteria. Further intensive study is being applied to this problem.

Very erratic is the destructive brown root rot of tobacco. The cause has long been in doubt. The Maryland station, in a study of the chemical and biological soil factors associated with the disease, found that the well-known soil pathogen (*Sclerotium bataticola*) not only could sometimes be isolated from affected roots, but is favored by conditions also favorable to the occurrence of the disease, and that in laboratory tests the fungus produced symptoms on tobacco resembling those of brown root rot. Using affected soils, mostly from Massachusetts, the Wisconsin station with the Department (B.P.I.) studied conditions productive of brown root rot effects and those that prevented them, although the causal agent was not determined. A wide variety of plants, particularly legumes, were found susceptible, and information was acquired which may help eventually to solve the problem. Another soil-borne disease is black shank whose destruction has been stayed by the development of resistant varieties. In the work of developing superior types of cigar-wrapper tobacco, the Florida station has constantly selected for black shank resistance combined with other desirable qualities. Two new resistant varieties, Rg and 301, have proved especially acceptable.

Recent increased emphasis on tobacco-disease research with growing inter-State and Federal-State cooperation may be attributed in considerable measure to the Tobacco Disease Council of station and Department workers formed in 1935 to help meet the need for more effective and better coordinated work in this field.

TOBACCO INSECTS

Active work was pursued in several States during the year on a number of troublesome tobacco insects and their control and a set of recommendations for the control of tobacco insects in 1939 was prepared by the Tobacco Insect Council, a group of workers from the States and the Department (B.E. and P.Q.), and published in Connecticut, Virginia, North Carolina, South Carolina, Kentucky, and Tennessee for the use of growers and farm advisors. Studies on tobacco insects of North Carolina by the station in that State and the Department (B.E. and P.Q.) disclosed that the tobacco flea beetle caused severe losses of newly transplanted plants due not only to the feeding of adult beetles on the tops but also to the feeding of the grubs on the roots and in the stems. At the Connecticut Tobacco

station in work with the Department (B.E. and P.Q.) rotenone-containing dust or spray appeared promising for thrips control, while dichloroethyl ether applied at transplanting time proved most effective against wireworm among some 10 soil fumigants or repellents, although in warm weather this volatile material may possibly burn the plants. However, its long residual repellency seemed to warrant further investigation.

SUGAR-PLANT DISEASES

That sugarcane can be grown at reasonable cost, and with little loss from the virus-induced mosaic disease, in practically any part of the Cane Belt by careful seed selection, proper isolation of seed plats, and thorough, adequately supervised roguing is indicated by 2 years' work of the Louisiana station. Continuing its studies on chlorotic streak of sugarcane, believed to be of virus origin, the same station presents further data on the local distribution of the disease and reports promising results on control by seed treatment, especially by the hot-water method.

The use of sugar beet varieties resistant to the virus-induced curly top disease has removed much of the danger formerly threatening the destruction of this industry in parts of California, Colorado, Idaho, and Utah, according to work by the California, Utah, and Idaho stations with the Department (B.P.I.). Providing another step toward the goal of better regional adaptation, the selection of resistant individuals is said to have given rise to a number of very resistant strains, which are described. Furthermore, the New Mexico station reports increased yields of approximately 6 tons to the acre in commercial fields from the use of resistant seed produced in the State by methods developed at this station.

Pythium-induced damping-off was found by the Iowa station to have been responsible for sugar beet failures on acid soils at moderately high soil temperatures in northern Iowa, causing over 95 percent of damage to seedlings. Temperatures below 59° F. proved unfavorable to the growth and pathogenicity of the fungus. In field tests early planting increased both emergence and survival, as did seed treatment with ethyl mercury phosphate, especially in early plantings, while liming mainly increased survival. According to greenhouse and field tests by the California station, damping-off of sugar beet seedlings was likewise usually controlled to a practical degree by seed treatment. Red copper oxide proved effective when *Pythium* was the causal factor, but with *Rhizoctonia* or with seed-borne *Phoma* the organic mercurials were more effective. Planting had to be done at once to avoid injury by the organic mercurials. Recent work by the Minnesota station has contributed toward greater efficiency in experimental methods for field and greenhouse studies of this group of diseases.

As a culmination of 5 years' research by the California station, the once greatly feared southern root rot no longer seriously threatens the sugar beet industry in central California where over 14,000 acres are known to be infested. Spread has been checked by proper handling of screenings from beet-loading stations, wash water from factories, agricultural machinery, and of livestock from infested fields. Most important was the discovery that the fungus builds up in soil prin-

cipally on sugar beets and that the fungus "seed balls" (sclerotia) diminish rather quickly in the soil when beets and other susceptible crops are not grown. By proper rotation and field management, after 3 to 5 years sugar beets could again be safely grown on previously infested soil. Nitrogenous fertilizers have also reduced infection as much as 50 to 75 percent, but their use is limited by the cost. Of great help is a new method of soil analysis developed by the station by which the number of living seed balls in the soil and the fitness of any field for sugar beet culture may be determined before planting.

In the coastal areas of California, downy mildew may infect 60 to 80 percent of the stand and may reduce sugar beet yields 3 to 5 tons per acre where infections occur within 125 days after planting. California station tests showed that certain varieties have a degree of resistance. A crown rot known as "charcoal rot" of sugar beets occurring only in the interior valleys of California and apparently depending on high temperatures was found by the same station to be due to a fungus described as *Macrophomina phaseoli*.

SUGAR-PLANT INSECTS

The distribution of the beet webworm has been shown by the Montana station to depend on certain climatic factors, its southern limits extending to the regions with annual mean temperature of 55° F., and its eastern and western limits to those with annual mean rainfall of 25 inches and 10 to 15 inches, respectively. Except for occasional outbreaks due to climatic fluctuations, it is held unlikely that this insect will become a problem outside the area thus delimited.

Introduced by the university station, a wasp parasite (*Larra americana*) of the mole cricket, a pest of sugarcane and other crops in Puerto Rico, had become established at the point of release in greater abundance than where collected in Brazil. Past failures to get many of the wasps to Puerto Rico alive were turned to success when eggs of the wasp were shipped with mole crickets in the same containers.

That the sugarcane rootstock weevil is continuously active through the year and is able to feed on a number of wild plants as well as on corn and sorghum are among important facts worked out by the Louisiana station in its study of this pest destructive to both plant and stubble crops in the State.

Stem galls on sugarcane may be induced by green leafhoppers (*Draeculacephala mollipes*) as demonstrated by the Hawaiian Sugar Planters' station by inoculating embryonic cane tissues with an extract of crushed insects.

FORAGE AND COVER-CROP DISEASES

Studies of the covered kernel smut fungus of sorghums by the Minnesota station have indicated far greater variability, more differences in pathogenicity, and more deviation from the normal than hitherto supposed. Experiments which included hybridization within the species gave evidence that new physiological races can arise in nature and must be taken into consideration in developing effective methods of control. Studies by the same station of 200 strains of the *Septoria* leaf blotch fungus of brome grass from 4 Minnesota localities

indicated many consistently different types falling into 4 groups corresponding to the locality from which isolated. Common brome grass appeared to be the only susceptible one of 34 species of this group tested, but inbred lines of this grass differed greatly in susceptibility.

Continuing its studies of the susceptibility of forage grasses to cereal smut fungi, the Washington station with the Department (B.P.I.) has added 4 grass species as new hosts of the 2 bunt or stinking smut fungi of wheat. The evidence obtained indicates that the fungus filaments overwinter in perennial hosts and that their persistence is probably influenced both by the degree of susceptibility of the host and by its predisposition to drought or winter injury. Furthermore, 4 collections of covered smut from barley and from 2 grass species proved pathogenic to 6 of 25 other grass species tested, and 3 of the latter also proved susceptible to barley loose smut. All possible crosses among the 4 covered smut collections proved pathogenic to both grass and barley hosts.

In studying the host-parasite relations of the downy mildew fungus of millet grasses, the Iowa station found that infection of young seedlings takes place through various parts of the top and roots, but more particularly at the crown (coleorhiza). Directly penetrating the surface, the parasite grew both between and within the cells toward the embryonic stem tip, from which it entered the young leaves.

Root rot of alfalfa was found by the California station, with the Department (B.P.I.), to be due to a fungus (*Stagonospora*) hitherto known chiefly as a leaf-spotting pathogen which also proved capable of inducing a root rot of sweetclover. The root rot was found to develop slowly and to be favored by high temperatures, though the leaf-spot form developed at low temperatures in the early spring and late fall.

The cowpea is an important crop in many parts of California, particularly in the San Joaquin Valley, where, because of the high temperature and low humidity, it is the only crop of this nature that can be grown. In recent years the spread of nematodes has destroyed this crop in many fields and practically eliminated its production in some areas. The cowpea wilt and charcoal rot diseases have also seriously reduced yields. The California station has reported practical completion of the development of commercially acceptable varieties possessing high resistance both to the nematode and to these two diseases. The Alabama station has recently developed a rapid greenhouse method for determining resistance to the nematode-induced root knot satisfactory for both beans and cowpeas but not for lima beans.

According to microscopical studies of red clover plants resistant and susceptible to powdery mildew, reported by the Wisconsin station and the Department (B.P.I.), the highly resistant plants were found to stop the progress of the fungus soon after its entry, due to an antagonistic reaction between host and parasite. In moderately resistant plants the fungus became initially established in much the same manner as in the susceptible ones, but it was usually reduced in size.

The Georgia station continued its studies of the two *Cercospora* leaf spot diseases of peanuts. In investigating the value of sulfur dusts for disease control, it was found that the yields of both nuts and peanut hay were increased, the quality of the hay was improved, and the spread of the leaf spots and excessive shedding of the leaves were effectively

prevented. Increased yields were considered due partly to disease control and partly to some action of the sulfur in the soil. Progress was also reported in the development of leaf spot-resistant strains of peanuts. The North Carolina station reported that for many years growers have been planting peanuts from previous crops on the farm without regard to diseases, with resulting heavy losses when conditions were favorable for parasite activities. These losses were attributable to several different parasites, mostly fungi, which live over from year to year in the seed coat. This work indicated that early losses and poor stands are due to plantings of diseased seed, thus pointing to means of prevention.

FORAGE AND COVER-CROP INSECTS

In a study of the biology and control of the annual white grub, which for several years has seriously injured lawns in Ohio, the Ohio station found a carbon disulfide-rosin fish-oil-soap emulsion to give the highest mortalities of this pest. However, an arsenical treatment is favored because of its known residual effect.

Studies of the chinch bug pest of sorghums by the Kansas station, with the Department (B.E. and P.Q.), indicated the possibility of reducing its depredations through host-plant resistance. Investigating most of the important standard sorghum varieties, it was found that in general the milos and feteritas are susceptible, while the kafirs and sorgos are usually rather resistant. The biology and control of the sorghum webworm has been studied by the Texas station, which found that six broods and a partial seventh are produced each season in that State, as compared to the three reported from Missouri. Use of insecticides has proven impracticable, and the chief dependence for control is said to lie in methods of crop management. Although chinch bugs are attacked by several parasites, these are not deemed effective in preventing injurious infestations.

Continuing its studies of lygus bugs, which seriously limit alfalfa-seed production, the Utah station has published a bulletin discussing the type of damage inflicted on the plant, the life history of the bugs, and the possibility of their control with currently available insecticides.

In a field study of the hibernation habits of the cowpea curculio, the Georgia station found that in this region the earliest-planted crop bears seed about July 1, the time of maximum emergence of this pest. Comparative freedom from injury was shown by cowpeas coming into bearing about September 1, provided no earlier plantings were nearby. Investigations of the host plants and parasites of the cowpea curculio and other legume-infesting weevils in Georgia, embracing some 20 species of wild and cultivated leguminous plants, disclosed numerous other pests and their parasites in the seeds, including 7 species of weevils. Studying the life history, habits, and insecticidal, natural, and agronomic control of the cowpea curculio, the Alabama station found that string beans, cotton, strawberries, and other crops serve as food for the adults, principally before cowpeas become available, and that 2 generations occur annually in the State. A tachinid fly and several species of ants are said to be its most important enemies, and hot, dry weather to be the most important climatic factor in its natural control. Certain garden varieties proved more resistant to attack than

others, but it is believed doubtful whether any of them are sufficiently resistant to escape injury in the absence of more susceptible ones. It is stated that when the pods are stored on a tight, dry floor the larvae perish. For field control, calcium arsenate was significantly the most efficient insecticide tried, with sodium fluosilicate next in order and on the whole most satisfactory.

The potato leafhopper on peanuts, under study by the Virginia station and the Department (B.E. and P.Q.), is said to be the most important insect pest of this crop in the State. It is often extremely abundant in Virginia and North Carolina during July and August. A burning of the leaf tips and margins and a yellowing and dwarfing of the foliage are common effects. On the basis of the experimental data, three applications of bordeaux mixture as a spray or three of sulfur as a dust are recommended as producing very profitable increases in yield of both fire-cured nuts and peanut-vine hay.

POTATO AND SWEETPOTATO DISEASES

No disease invader from abroad has aroused more apprehension among potato growers than the bacterial ring rot and wilt reported first from Maine in 1934. By 1939 the disease had spread to at least 20 States scattered from Canada to the Gulf and from the Atlantic to the Pacific. A number of stations and the Department (B.P.I.) are making a coordinated study of the disease and its manner of spread as a basis for the prompt establishment of protective measures to hold it in suppression. The Maine station found that the disease, though not perpetuated in the soil, is perpetuated by the tubers used in planting and is thus able to increase from a mere trace one season to 40 percent in the next crop. By the planting of healthy seed only, as recommended by the station, the disease, which prevented certification of 28 percent of the acreage of Spaulding Rose submitted in 1937, appeared in only one small field of this variety in 1938. A Maine station bulletin on this disease reported losses approaching \$80,000 in the State in 1938. The New York (Cornell) station demonstrated bacteriologically that the disease is identical with the ring rot reported in Germany some years ago. The Colorado station showed that germs from infected tubers were transmitted by the cutting knife to 70 percent of the healthy tubers in a test seed lot. Seed treatment after cutting was found helpful in reducing such infection. The California station found the disease to be a precursor of the bacterial soft rot which is very destructive in an important potato-growing district. Such rot bacteria have also caused heavy losses in potatoes shipped from certain southern Florida points but the Florida station found that heating the potatoes for a few minutes to 150° F. prevented the rot. The installation of a commercial high-temperature drier capable of handling several carloads per day, resulted in not a single report of bacterial rot by terminal inspectors in shipments from this drier during the season.

In continued research on the common scab disease of potatoes, five wild relatives of the potato were found by the New York (Cornell) station to be entirely unaffected by scab in heavily infested soil. Though themselves undesirable from many angles, some of these may prove valuable as parental lines for breeding to combine scab resistance

with commercially useful qualities. Great variations in scab susceptibility were noted by the Wisconsin station in standard potato varieties in different seasons or in different localities or soil types, indicating the complexity of evaluating disease resistance adequately in new potato strains. Differences in pathogenicity in different physiologic races of the scab fungus also complicate the problem, according to the Minnesota station, which is studying the inheritance of resistance factors. The Virginia Truck station found that the use of acid-forming or nonacid-forming fertilizers had no direct influence on the severity of scab attack, the latter being dependent on the final soil reaction. In Sassafra sandy loam no scab developed where the soil was more acid than pH 4.85 although able to grow between this and pH 5. Adjusting the soil reaction to the desired point and keeping it there with nonacid-forming fertilizers was held advisable. The Wisconsin station with various scab-infested soil types adjusted the reaction to different levels and found that the disease decreased as the acidity increased but did not disappear entirely even where the soil was held below pH 5 for 2 years. No reduction of scab was achieved by lime at 8 tons per acre which changed the reaction to pH 8. The Michigan station summarized information regarding scab susceptibility and control based on extensive research. Regarding another tuber blemish, silver scurf, the New York (Cornell) station found that prompt harvesting and cold, dry storage may be valuable preventives.

Bacterial brown rot of potatoes is troublesome in some soils of the South. The Florida station reported that after 4 years, the disease was still under control in a field treated with a single summer application of 800 pounds of sulfur to eradicate the germs, followed by 3,000 pounds of limestone in the fall to counteract the resulting high acidity which is injurious to potatoes. A very thorough investigation of the process of cork formation in diseased and healthy potatoes made by the West Virginia station provides hitherto unknown facts that will be helpful in working out methods to promote healing and reduce decay.

Another troublesome soil-borne potato disease (*Rhizoctonia*) prevalent from coast to coast, has been difficult to deal with by ordinary methods. The New York (Cornell) station while investigating the effects of common farm practices found that growing potatoes on the same ground year after year caused an increase in the disease. It also found that, even with continuous potato culture, the use of stable manure, commercial fertilizer, or a rye cover crop, or best all three combined, definitely reduced the amount of fungus on the tubers.

Air-borne diseases like late blight (*Phytophthora*) and early blight (*Alternaria*) are controlled chiefly by spraying. Tests by the Louisiana station indicated that in that State growers can save money by applying bordeaux spray only in years when the early blight appears at least a month before digging. Demonstration by the North Dakota station that a high concentration of this spray applied to young plants decreases yields while a low concentration gives an increase, confirms results of station work in the East. The moot question as to whether potato plants become more susceptible to late blight as the season advances was studied at the New York (Cornell) station by simultaneously testing plants of five varieties grown in part under long-day and in part under short-day conditions in the greenhouse. No variety

showed susceptibility differences under long- and short-day conditions great enough to be of practical significance.

In dealing with the spread of virus diseases, knowledge of the insects that are responsible for their transmission is exceedingly important. In a 3-year study the Oregon station with the Department (B.P.I.) found certain kinds of aphids effective in transmitting some of the important potato viruses while flea beetle, tarnished plant bug, leafhopper, and two insects of lesser importance were ineffective. Using microchemical methods, the West Virginia station determined chemical differences between healthy potatoes and those affected with the blue stem disease, probably of virus nature. The information will be widely useful in establishing norms for healthy potatoes in studying other maladies as well. A disease called blind sprout, of unknown origin and nature, is under investigation by the New Jersey station. Affected sprouts may be delayed in emergence from 6 weeks to 2 months, the tips are blunt, and poor yields result.

Consistent improvement of sweetpotato stands and quality is the result of experiment station work on disease control. The New Jersey station, testing the efficacy of a mercurial treatment against sweetpotato scurf, found that dipping both seed potatoes and sprouts resulted in 92 percent scurf-free crop as compared with 7 percent for the untreated controls. The Delaware station also found this type of treatment helpful, but in addition found it desirable to produce seed from slips grown on disease-free land or at least selected at the time of digging, which should be done prior to October 10, and to practice annual renewal of the seedbed soil, early planting, and crop rotation. This station also found that the use of yellow copper oxide in plant treatment increased the control of black rot and other diseases from 75 to nearly 90 percent.

POTATO AND SWEETPOTATO INSECTS

By a study of the weather conditions and associated abundance of flea beetle and psyllids in potato fields, the Colorado station was able to draw conclusions armed with which the Colorado growers were prepared in 1938 to use defensive measures in time and reduce psyllid damage by over \$4,000,000. This station also found that the use of sulfur, sulfuric acid, or the sulfates of iron, aluminum, and magnesium added to complete fertilizer rendered potato plants more resistant to the insect so that fewer insecticide applications were needed. Of the insecticides tested, sulfur applied in dust form best combined effective control with least interference with plant health and vigor.

Prevalent in many potato-producing sections is the leafhopper which causes the tipburn of leaves and yield reduction. The New York (Cornell) station found that although spraying with bordeaux mixture in western New York decreased the population of the leafhoppers in the field successfully, almost equal success was obtained by using pyrethrum dust. On Long Island, this station reported improved control from the use of pyrethrum-rotenone-sulfur dust and an increase of 43 bushels to the acre over the yield of potatoes dusted with copper-lime dust. The Wisconsin and Ohio stations have accumulated evidence that different potato varieties differ not only in resist-

ance to hopperburn but also in the numbers of hoppers found on the plants. Two new varieties, Houma and Katahdin, were found tolerant.

Both foliage and tuber damage result from flea beetle attack in many localities. The Ohio station reported four kinds of flea beetles working on potatoes. It was found that weekly applications of a calcium arsenate-bordeaux mixture spray gave best control with highest yields. Where copper-lime dust was used in place of spray the addition of calcium arsenate aided in flea beetle control. The North Dakota station surveying the potato tuber injury situation in the Red River Valley in 1937 found the wireworm *Corymbites aeripennis destructor* the leading cause of damage.

Highly effective results in cage tests were obtained by the Virginia Truck station and the Department (B.E. and P.Q.) by the use of calcium arsenate, barium fluosilicate, or synthetic cryolite against the sweetpotato leaf beetle which causes periodical damage in certain localities in the South.

TRUCK-CROP DISEASES

That environal factors have an important bearing on the incidence of sweet corn bacterial wilt was strikingly confirmed from a survey by the New Jersey station of a test planting of 18 varieties in which the land sloped very gradually from a well-drained area at one end to a section which remained moist for a much longer time at the other. Without exception there was more wilt, mostly over twice as much, on the lower half of each row than in the upper half. Further evidence was also reported of a relation between flea beetle population and the appearance of wilt. Disease incidence, though evidently controlled largely by the weather of the preceding winter, is modified by other factors. Consequently, wilt predictions based on winter meteorological records, though often remarkably accurate, can apply only to average conditions and may not hold true for particular fields. When mixtures of virulent and weak strains of the wilt bacteria were introduced into susceptible and resistant varieties of corn, the Iowa station found that the proportions of these strains changed with time, more of the virulent strains surviving on the resistant varieties. Virulent bacteria killed the susceptible host in 10 to 15 days but only stunted the resistant one, while weakly infective strains stunted but failed to kill the susceptible host and became limited to the first early lesions in the resistant one.

White rust of spinach, first noted in 1937 on the New York market in shipments from Texas where it was destructive during 1937-38, was found by the Texas station with the Department (B.P.I.) to be due to the fungus *Albugo occidentalis*. Certain of the large flat-leaved varieties are reported highly resistant. Downy mildew of spinach, present in nearly every country where this crop is grown, has been found in 24 States, with reported annual losses of 3 to 15 percent. Studies by the New York (Cornell) station indicated the 35 varieties tested to be about equally susceptible. Primary infection may come from infected seeds, soil, or overwintered plants, the last being most important under Long Island conditions. Wind and rain are important inoculating agents. Control by keeping overwintered spinach away from the winter- and spring-sown crops is suggested for Long Island conditions.

The California station reported and described a fungus soft rot of asparagus spears found to be due to a *Phytophthora* and associated with heavy and prolonged rainfall and perhaps also with the rather common practice of flooding certain areas to induce earlier growth.

In Colorado it was observed that onion roots invaded by the pink root fungus (*Phoma*) were not always typical pink red, but sometimes yellow or yellow brown. The Colorado station showed that temperature and nutrient variations had little to do with this but that increasing alkalinity produced color changes like those in the field. The pigment, isolated in a soluble state, shifted from a yellow-brown under acid to red-purple shades under alkaline conditions. The same station also found the *Fusarium* bulb rot of onions to be introduced only by injuries to the bulb. The New Mexico station, in studying the development of pink root and the associated bulb rot and false blossom blight in onions grown for seed, obtained several different fungi from diseased bulbs and leaves which are being further tested for possible relationships to these diseases. In treating onion plants with various chemicals before setting in the field, hydrated copper sulfate applied to the roots was found to kill the plants very quickly, while sulfur dust, copper carbonate dust, borax, formalin, organic mercury preparations, and corrosive sublimate did not injure the young plants. After nearly 10 years of selection and breeding, the California station expected to have adequate seed of a new pink root-resistant onion for distribution shortly. This station also discovered resistance to mildew, one of the most destructive onion diseases, in a male-sterile strain of Italian red onion. Progeny of about 25 crosses and 50 backcrosses between this and important commercial varieties were being tested for resistance.

The black ring virus disease of cabbage and its relatives, under investigation by the California station since 1932 and found chiefly during winter in the cool, coastal valleys of the State, causing marked yellowish or dead areas in the older, outer leaves, was readily transmitted by the cabbage and green peach aphids, and also by direct inoculation of juice from infected plants. All cabbage varieties tested were susceptible, as well as 22 other members of the mustard family and 19 species in 11 other plant families. This station also studied and described a mosaic disease of radish found in the San Francisco Bay section which was readily transmissible by mechanical means but not by the cabbage, green peach, or turnip aphids. Infections were obtained in 14 crop plants and various weeds of the mustard family as well as in 9 other kinds of plants, but failed in 52 further species tested. The New York State station controlled cabbage seed-bred injuries due to damping-off, wiry stem, and canker caused by the *Rhizoctonia* fungus, through soil treatment with corrosive sublimate or calomel.

The New York State station reported that bordeaux mixture sprayed on members of the cucumber-melon family causes dwarfing, leaf deformation, leaf-margin yellowing and necrosis, scorching of the leaf blade, accelerated water loss (transpiration), and defoliation. The lime portion of the fungicide definitely dwarfed the plants and deformed the leaves, while the copper appeared to injure only when solubilized by acid conditions. From the practical standpoint, the

tests indicated that both acid and alkaline sprays or dusts should be avoided on melons and cucumbers, and that neutral bordeaux is impractical because the margin of safety is too narrow. Use of one of the insolubilized copper compounds is therefore deemed preferable. The Louisiana station reported material progress in breeding and selection of cucumbers for resistance to downy mildew and in determining the factors responsible for it. The Puerto Rico University station has produced three superior strains of cucumbers acceptable to the New York market and resistant to this disease. Under no protection from infection, one of these is said to have outyielded commercial varieties by eight times the quantity of fancy and choice fruits.

The California station noted that although its powdery mildew-resistant cantaloup No. 45 appeared immune from 1935 to 1937, this disease was found on it during 1938. Immediate investigation showed the infection to be due to a second form of the mildew fungus. Certain cantaloups of foreign origin appeared to possess a degree of resistance to this second form. Breeding is in progress on the development of varieties resistant to both and a recently developed new Persian type was expected to be ready for early release. This situation well illustrates the eternal vigilance necessary for any continued protection of plants from the diseases to which they are or may become subject. *Fusarium* wilt has caused serious losses to the melon growers of New York. Two years of breeding experiments by the New York (Cornell) station have resulted in several wilt-resistant types outstanding for external and internal appearance, high quality, and appropriate size. Distribution of seeds of one strain has begun.

The California station reported a forthcoming Striped Klondike watermelon resistant to the wilt disease and ready for release in 1939 or 1940. A seed decay, damping-off, and root rot of watermelon seedlings was found by the Iowa station to be caused by a fungus, *Pythium irregulare*, which leads to the belief that field losses of seedlings are not entirely attributable to *Fusarium* wilt.

A soft rot of watermelon and Zucchini and Mammoth Summer Crookneck pumpkin fruits, described by the California and Missouri stations as prevalent in California and due to *Pythium ultimum*, is said to occur when the fruits are in contact with wet soil and to be favored by cool weather. The fungus also induced damping-off of pumpkin, watermelon, and tomato seedlings, but older plants were resistant. A watery root and fruit rot of watermelons, Honey Dew melons, quail muskmelons, and crookneck squashes in Arizona was found by the station to be due to another species of *Pythium* (*P. aphanidermatum*), which also proved capable of penetrating uninjured tissues and inducing a rapid decay of many other fruits and vegetables. The Colorado station reported that a prevalent fruit rot of squashes and watermelons was due to the pepper blight fungus (*Phytophthora capsici*).

The Oregon station with the Department (B.P.I.), in tests of squash varieties and strains for resistance to the curly top virus, found two Marblehead strains to exhibit outstanding resistance, while all others showed extreme susceptibility.

Spores of the fungi causing early and late blights (*Cercospora* and *Septoria*, respectively) of celery, according to the New York (Cor-

nell) station, may be disseminated on the clothing. Reported failures of some growers with fungicidal control practices may possibly be explained by such findings. The Michigan station reports that Cuprocide-sulfur-talc dusts gave superior control of the celery leaf blights in three plantings and had smoother flowing properties and better foliage coverage than any other materials previously tested. Furthermore, bordeaux mixture is said to have controlled leaf diseases without perceptible foliage injury more effectively than copper fungicides of low solubility, all of which caused sufficient injury to reduce yields.

In studies of five virus diseases of celery, spontaneous infection with western celery mosaic was demonstrated by the California station in celeriac and in varieties of celery and carrot. Various other economic plants of the family were successfully inoculated, and the properties and transmission of this virus investigated. It is said to be the limiting factor to production in certain areas of California and to have recently invaded the Sacramento delta. A search is being made for a resistant selection or foreign introduction which can be used in the breeding program.

A mosaic disease of turnips, reported as prevalent on Long Island, N. Y., was found by the California station to be readily transmitted both by certain aphids and by mechanical inoculation. The host plants were shown to include 18 species of 12 genera in 6 families, the majority being members of the mustard family, such as cabbage, cauliflower, and rutabaga.

Study of the foot rots of pod peas by the Colorado station showed that low fertility levels favored their very destructive occurrence on the light sandy loams of the San Luis Valley, and indicated that long rotations, disease-free seed, seed treatments, and maintenance of soil fertility should be used to reduce losses. The Wisconsin station reported that remarkable yield increases in canning peas were secured by fertilizing root rot-infested soil.

The New York State station called attention to the danger to common peas from seed-borne diseases of vetch, especially the leaf and pod spots (*Ascochyta-Myco-sphaerella* complex), perpetuated on wild vetches, and commonly in infected seed stocks of domestic- or foreign-grown commercial vetches. The fungus may survive for 1 to 7 years in dry seed. Disease-free stock was obtained by selection from non-spotted pods, and it is believed that the fungus may be eliminated by using seed naturally free from infection produced in certain western irrigated regions. The California station reports the finding of some varieties of peas which, though not immune yet show considerable tolerance to this trouble, and has made some crosses.

In investigating the possibility of chemically eliminating saprophytic fungi appearing in laboratory germination tests of seed peas, the New York State station found that proper use of mercury-containing dusts effectively controlled surface molds on the seeds without injury to the seedlings.

Evidence that the near-wilt disease of peas can be transmitted through the seed is presented by the Idaho station.

Continuing its work with the virus-induced common bean mosaic and curly top, the Idaho station reported 42 hybrid selections of the Great Northern type to be completely resistant to both, 7 of them

possessing desirable characteristics and giving excellent yields in areas where commercial varieties are seriously damaged. Many garden-bean selections had also proved resistant to these very destructive diseases and are said to show promise of development into commercially important varieties for Idaho. The Utah station reported that a white pea bean highly resistant to both mosaic and curly top had been developed and was ready for release, together with a typical pinto bean that is resistant to curly top but not to mosaic.

The Georgia station reported a severe chlorosis followed by wilt and death of snap bean plants, first observed in 1938 and even more destructive during the 1939 season. This trouble, apparently introduced on western-grown seed and believed not to have been previously described, appears to be of virus origin.

Corticium web blight, first discovered in the United States in Florida in 1932, has caused, during warm, rainy summer weather, total losses in extensive bean plantings, attacking and killing the aerial parts. The Florida station found that the fungus "seed balls" (sclerotia) produced on diseased plants may remain viable for at least a year, constituting a source of infection. The extremely pathogenic fungus was found capable of parasitizing a wide range of crop and wild plants. The life history of the fungus was determined.

In investigating the effect of bordeaux mixture on water losses (transpiration) by bean and tomato plants, the New York State station found that high temperatures on spray dates and the presence of water favored an increased water loss ("bordeaux transpiration"), while high temperatures afterwards failed to affect it. Studies over a 9-year period indicated that bordeaux may also dwarf tomato plants, kill the actively growing part (meristem), deform young leaves and fruits, cause bloom to drop, harden the foliage, decrease the growth cracks, and occasionally induce fruit russet, the net result being a reduced final yield. The way these effects were brought about was studied and conclusions were presented. The simplest solution appeared to lie in use of a neutral or lime-free copper spray, and tests with red copper oxide appeared to point to its dependability. The latest tests indicated that spraying can be delayed apparently until the first leaf dies from blight, which means that no spraying need be done in blight-free years, thus saving expense and avoiding danger from spray injury.

Since early blight is the most damaging tomato disease in the State, at times reaching epidemic proportions, the Wisconsin station has made an intensive study of the disease and methods of controlling it. The pathogen may be transmitted through the seed, which may remain infected for at least 9 months. Work with disinfectants indicated that they may have at least some effect on the fungus beneath as well as on the seed coat. Early blight often starts in small isolated areas in the seedbed or field, and under favorable conditions spreads so rapidly that from a few infected seeds or a small infested area of soil an entire seedbed or field may become infected. Collar rot is a serious manifestation of seedling blight. Rotation experiments conducted by the Georgia station with the Department (B.P.I.) indicated that a 1-year rotation of other crops between plantings of tomato seeds is insufficient to free the soil of early blight infection. Of several materials tested for the control of seed-borne diseases of tomatoes, both New

Improved Ceresan and New Improved Semesan, Jr., as dry dusts, are said to have given good control with ease of application and low cost.

The annual production of marketable greenhouse tomatoes in Massachusetts is said by the Massachusetts station to approximate 1,110 tons with an annual gross value of \$283,700, but these figures represent but two-thirds of what might be gained if the tomato leafmold disease (*Cladosporium*) alone were eliminated. Favorable conditions for infection that are often beyond reasonable or practical means of control commonly occur in the greenhouse, and the disease is usually epidemic indoors in eastern Massachusetts from June to October. Following a long-time study of the reactions of many sorts of tomatoes and tomato relatives, hybrids were made between common tomato varieties and the red currant or raisin tomato, which possesses resistance to leafmold. As a result of this program a forcing tomato—Bay State—said to promise all the desirable features of Waltham Forcing and at the same time to be resistant to the disease, has now been offered to the public and is already in limited commercial production.

For leaf spot on tomatoes, the Ohio station found three applications of fixed copper sprays, the latter part of the season or just after the disease appeared, to give satisfactory control, thus eliminating the expense of keeping the vines covered throughout the season.

In plant-pathological investigations, the characteristics distinguishing pathogenic from nonpathogenic organisms are of very considerable importance. In a study by the West Virginia station of the *Fusarium* causing tomato wilt, a substance given off by the fungus in fluid culture and isolated in greatly purified crystalline form was very toxic to tomato plants when cut stems or roots were immersed in solutions containing it. It is believed to be the substance enabling this fungus to attack and cause wilting in tomato plants. In testing 59 named tomato varieties, the Texas station found 8 highly resistant to this disease. The Michigan station reported the development of a wilt-resistant strain of John Baer, otherwise similar to the commercial variety and thought to be adapted to all regions where it is grown and to compare favorably in resistance with such well-known varieties as Marglobe and Pritchard. On heavily infested soil this strain yielded 20 tons per acre, as against 8 tons of the commercial John Baer.

The Florida station published a bulletin detailing the results of experimental work and presenting a compendium of information on the tomato nailhead spot disease (*Alternaria*) known in the State for 25 years and said to be responsible for millions of dollars' damage to this crop in Cuba, the West Indies, Mexico, and the United States. Potato, eggplant, and horsenettle are all reported to be susceptible. The use of resistant varieties is the most effective line of attack.

A serious fruit rot of tomatoes in the field was found by the Colorado station to be caused by the pepper blight fungus (*Phytophthora capsici*).

Although bacterial canker of tomato is known to be seed-borne, the California station reports that field trials with plants grown from untreated seed harvested from diseased plants gave less than 1-percent infection, and that the canker bacteria failed to persist in field soils from one season to the next, though this may occur in

plant beds. The principal spread occurred during the process of topping the plants with a knife prior to transplanting or by handling during the transplanting operations. By this means a low percentage of infected seedlings in the beds may be sufficient to start an epidemic.

A new tomato virus disease, tip blight, was described on the basis of a 4-year study by the Oregon station. Typically developed in the tomato-canning counties of southern Oregon, yields have frequently been very seriously reduced by it. The amount of tip blight present and its dissemination were influenced, as with spotted wilt which it resembles, by the abundance of its insect carrier—a species of thrips—and by the availability of the weed hosts. Various indirect methods of control were outlined, and some progress was reported in the isolation and development of resistant strains of tomato.

Based on years of extensive trials and selection work, the Utah station reported several selections of wild and novelty-type tomatoes that exhibit a degree of resistance to the curly top virus far surpassing that of any selections previously made either there or elsewhere. They have done so well in the commercial tomato district of the State that they have been used as parents in breeding for combined resistance and desirable market characters. Similar resistance to the *Verticillium* wilt disease is reported for a Peruvian wild tomato. Considering the standard field-plat technique of measuring the relative resistance of tomato and bean varieties to curly top as unreliable where inoculation depends on a migratory insect vector, this station developed a method that has proved fairly reliable over a period of 5 years. In further work by the California Citrus station with the Department (B.P.I.), it was found that plants affected with curly top sometimes recover from the symptoms and acquire a tolerance to the virus. However, the virus was readily obtained from recovered plants apparently unchanged in virulence when tested on healthy plants. The California station reports that since no mechanical inoculation method is known that gives 100-percent infection of spotted wilt—another virus disease of tomatoes and other hosts—all its tests for resistance are made in fields where the disease ordinarily assumes epidemic proportions and is transmitted by its natural thrips vector. A large number of selections and hybrids are being tested for resistance to spotted wilt under these conditions.

Root knot nematodes, according to the Indiana station, cause serious losses to the canning-tomato crop in Indiana, where they occur primarily in fields set to plants originating in the South. The set and size of fruits are reduced, resulting in losses of income as high as \$32 per acre. Furthermore, early blight appeared to be more severe on the nematode-infested plants. No evidence was obtained for the winter survival of this pest in the open in northern Indiana, but since it had been known to live over in Ohio and New York, rotations with immune crops were advised. Examination of tomato plants for infestation before setting out, with rejection of infected lots, was also recommended.

Proof by the California station that *Verticillium alboatrum* is capable of producing a fungus wilt of peppers of a type recently reported from California and Connecticut suggests the possibility that this fungus rather than *Fusarium* may have been responsible for some of

the wilts formerly attributed to the latter. The station reports that the spotted wilt virus has been the cause of practically complete losses of this crop in some of the southern California coastal production centers. A source of resistance is being sought in a collection of over 200 lots of peppers. A mosaic disease which is causing great damage to peppers in Puerto Rico is said by the university station to have been found mainly due to an unidentified virus ("mottle virus") and, to a lesser extent, to the virus of ordinary tobacco mosaic.

The Puerto Rico University station also reports the development of two new strains of eggplants of superior quality said to be resistant to bacterial wilt (*Phytophthora solanacearum*). The special value of these strains lies in the fact that this wilt occurs in many parts of the island and uninfested soils become infested after continued culture of eggplant, pepper, or tomato.

TRUCK-CROP INSECTS

Sweet corn growers are reported to be taking advantage of the results of scientific research on the control of the European corn borer. Both the Virginia Truck and Ohio stations have noted highly significant and encouraging differences in resistance or tolerance to the corn borer among different strains of corn, the Ohio study being based on observations conducted in the widely distributed cooperative test plats developed as a part of its extensive corn-breeding program. Sprays of powdered derris have been reported as very effective against this borer in the experience of the Massachusetts station. Field tests in 1938 showed that powdered cube root was as effective as and considerably less expensive than derris. These materials, however, failed to adhere as well as dual-fixed nicotine, which was better able to penetrate to the base of the central leaves.

The chief blame for the nearly complete absence of sweet corn in the Southern States has been placed on the corn earworm. This insect is also a most serious cause of losses in the North. North Carolina station tests demonstrated that applying highly refined mineral oil with an oilcan to the ends of the clipped silks resulted in 100-percent freedom from worms as compared with 96 percent and 92 percent when lead arsenate with a wetting agent was applied to the clipped silks from above with a solid stream jet. Leaving the silks unclipped resulted in decreased protection, and untreated checks suffered 20 to 65 percent worm infestation. The Maryland station reported basic studies on the effect of food variations on the physiology of the insect, while the New York State station, studying the influence of climatic conditions, found that severe winter conditions reduce earworm attack on early sweet corn on Long Island the following year. The Puerto Rico Federal station has found that excellent control is made possible by applying a mixture of mineral oil and pyrethrum extract to the silks soon after pollination, the same procedure being effective against the fall armyworm and the corn silk fly, important sweet corn pests on the island. The control of these insects will make it possible for the markets of continental United States to be supplied with fresh sweet corn during the winter months.

The White Persian onion is reported by the California station to be tolerant to damage by thrips, and progenies from crosses and back-

crosses with important commercial varieties are being tested for resistance. In 5 years' field tests under irrigation, reported by the Connecticut (State) station, the combination of pure ground cube root with a suitable spreader apparently protected onion plants from thrips when begun before severe infestation. Irrigation had no marked effect on the numbers of this pest.

Several years' dusting and spraying experiments by the Ohio station against the imported cabbageworm, cabbage looper, and larvae of the diamondback moth, insects that seriously damage the leaves of cabbage and related crops in the State, led to the recommendation that the cabbage crop be dusted or sprayed at 10-day intervals with paris green or derris powder, including a spreader and sticker. Five species of parasites were found by the Hawaii University station to attack the cabbageworm in Hawaii. The most important of these, *Apanteles glomeratus*, proved more effective at low than at high elevations, and when pyrethrum insecticides rather than arsenicals or rotenone were used to control its host insect.

A second season's work on the long unconquered squash bug by the Colorado station is reported to have shown that, at a cost of \$35 per acre, this pest can be controlled and a 5- to 8-ton yield increase obtained over untreated fields. The best results were obtained by a mixture of Dry Pyrocid and dusting gypsum.

The most destructive pest on cucumbers, melons, and cantaloups in the eastern half of the country is said to be the striped cucumber beetle. Tests at the Mississippi station indicated derris root containing 0.75 percent of rotenone to give the most effective control of any material tried. A mixture of copper oxychloride, calcium arsenate, and flour or talc also gave good results. The derris dust somewhat reduced infestations by the pickleworm, another serious pest. The Colorado station, using a contact poison combined with a repellent, obtained protection of melons and Honey Dews from the striped cucumber beetle at an approximate cost of \$1 per acre for each application. Two to four treatments a season are required.

The carrot weevil as a new pest on celery is reported by the New Jersey station, which published a general account of the insect and its control, including the results of 2 years' tests of insecticides. The role of aphids as transmitters of virus diseases of celery in California has become increasingly important. With the greater financial losses has come the need for more information about them. The California station presented an account of 11 species, mostly introduced, met with on celery in that State. Most of these potential carriers have a number of host plants, and all appear to reproduce throughout the year.

The Texas station issued a warning to vegetable growers in the coastal districts regarding the Hawaiian beet webworm, a source of losses in Galveston County for several years, early fall beets having been completely destroyed. Control experiments have led to the recommendation of pyrethrum-sulfur mixtures applied every 7 to 10 days, commencing when the plants are 2 to 3 inches high.

Studies by the Wisconsin station show how the time of appearance of winged offspring of the pea aphid is associated with nutritional conditions that cause an accumulation of excess proteins and carbohydrates, which appear to initiate wing development, thus permit-

ting wider distribution of the pest. Lack of these substances or a sufficient volume of fluid intake to carry them away as honeydew appeared to continue the wingless condition. In the face of an aphid infestation that threatened to destroy much of the canning-pea crop, research work by the Maryland station led to control by rotenone-bearing products with commercial effectiveness in most fields, and materials and methods of application were developed which should prevent future major damage from this destructive pest. Preliminary results with insecticides against the pea aphid at the New Jersey station have been further confirmed in that nicotine in all its forms showed an immediate high killing power while derris showed comparatively slow but much more prolonged killing power. With treatments well carried out, the peas showed practically no injury at harvest, whereas untreated plants had then been completely destroyed. For pea weevils, the Idaho station reports that proper use of border trap-crop strips in commercial fields materially reduced the acreage of peas that otherwise would have needed insecticide dusting.

Protection against Mexican bean beetles obtained by the South Carolina station from applying derris to bean plants in the field was found in general to last no longer than a week. The New York State station, comparing the effectiveness of two cube powders in spray and dust mixtures for controlling foliage pests of beans on Long Island, found that mixtures containing cube powder of 2-percent rotenone content and 18 percent of total ether extractives were as effective at the dosages used as those containing cube powder of 5-percent rotenone content and 12 to 14 percent of total ether extractives. In field tests of spraying or dusting with copper-lime mixtures for plant-disease control it was observed that bordeaux mixture possessed considerable merit in notably reducing the amount of feeding by Mexican bean beetles, and that this effect was slightly enhanced by the use of cube powder in the application or afterward.

Studies of the tomato bug by the Hawaii University station showed that plant injury by the bugs was more marked under prevalence of mosaic disease, root knot nematode attack, poor nutrition, and possibly also under high temperature conditions. In work by the Colorado station, no marked differences in effective killing of the tomato psyllid were obtained with various types of sulfurs or lime-sulfurs, all giving high kills, but three applications proved more effective than one or two in controlling the insect and preventing psyllid yellows. Lime-sulfur sprays, however, reduced yields, apparently through injury, but dusting and wettable sulfurs increased yields over controls and were satisfactory insecticides. According to the Colorado station, corn earworm attacks on tomatoes were reduced from 21 to about 1.5 percent, at a cost of \$3.40 per acre, by the use of a contact poison combined with a repellent. Five other insecticides were tested, one at a cost of \$1.50 per acre reducing worminess to about 4 percent. The Florida station found the life cycle of the tomato pinworm to be as short as 21 days during June. Under favorable conditions its parasites became sufficiently numerous to offer an important check. The most potent means of spread from one district to another was said to lie in shipments of infested plants, fruits, and containers. Pinworms were unable to mature

on wild Florida tomato, nightshade, or pepper plants, and the feeding of the larvae was confined to tomato, potato, eggplant, and a few other solanaceous hosts. The necessity for turning under all infested material remaining in the field after harvest was emphasized. The California station has published a comprehensive bulletin reporting work with various caterpillars attacking tomatoes and discussing their control.

Continuing its work with the garden centipede, 1 of 54 species of symphylids (exhibiting striking affinities with insects) of the world, the California station found that it may molt more than 50 times throughout its life, which may last 4 years or longer. It appears to be a vegetable feeder and prefers succulent materials, although it feeds also on many kinds of lower plant life. In certain areas it is a serious pest of cultivated crops.

Directed towards the control of various garden insect pests, the Idaho station has carried on experiments to determine the effectiveness of rotenone-bearing dusts which will control some pests and not others even of closely related species. Its use, therefore, must be tested for each insect. One recent season's tests have appeared to indicate its effectiveness against flea beetles and cabbageworms but not against cabbage aphids, while preliminary observations have given promise for its use against celery loopers and blister beetles.

ORCHARD DISEASES

Five-year apple scab control spray tests by the New York (Cornell) station in one orchard showed that fruit-tree yields were improved $3\frac{1}{4}$ bushels per tree per year with full liquid lime-sulfur schedule, but when flotation sulfur was used in all applications the increase over unsprayed was $7\frac{1}{4}$ bushels per tree. In spite of the tendency of the lime-sulfur to injure foliage, its superior effectiveness for scab control made its use imperative under severe scab conditions. The Iowa station also reinvestigated the apple scab spray program over a 5-year period and found nothing equal to lime-sulfur. Determining the time of scab spore discharge from the old leaves was found essential for proper timing of the first spring spray. The spraying of old leaves on the ground in the spring was viewed as a possible supplementary control measure. Reviewing 15 years of tests and observations, the Ohio station found that successful use of unusually mild or dilute sprays depends very largely on timeliness and thoroughness of application. Rightly timed and applied throughout the season, wettable sulfurs controlled apple scab satisfactorily. Such was also the conclusion of the Massachusetts station. For apple sprays following bloom the Ohio station found it advisable in general to use half the strength used before bloom. Flotation sulfur, precisely applied, controlled most fruit diseases without injury to leaves while ordinary lime-sulfur sometimes reduced leaf size up to 25 percent. The Pennsylvania station, using an experimental design that permitted statistical analysis of 24 different treatments, learned that under the conditions then prevailing lime-sulfur, diluted 1 to 75, appeared to provide the best balance between injury and control, but final conclusions awaited a study of conditions in other years. Additional work by

the Virginia station confirms the finding that best apple foliage condition existed where a copper-containing material had been used in the cover sprays due to the corrective action on lead arsenate. Early sulfur-containing sprays appeared advisable, followed by copper spray with an arsenical where the fruit would tolerate copper. No fungicide tested was satisfactory for use with fixed nicotine spray for apple worms. The Indiana station found that counts of leaf infections gave a good index of the comparative effectiveness of various scab spray materials and spray schedules and provided some guide as to the intensity of spraying demanded the following year.

Recently the Oregon station, dealing with pear scab control in the light of several years' work at Hood River, reported that a properly applied dormant spray helped to eradicate the hold-over stage although sulfur fungicides were desirable for spring protection.

Besides scab, apple growers have to fight a number of other diseases. That various "insoluble" copper materials are effective against apple fruit spot, sooty blotch, and flyspeck, but unreliable against bitter rot though causing much less fruit injury than bordeaux mixture, was the conclusion of the Delaware station. Thirteen leading apple varieties were tested by the Iowa station for susceptibility to strains of the common cedar rust from seven States and from various Iowa localities. Not only did these varieties differ markedly in susceptibility but at least four biological races of the fungus were found, each attacking certain varieties differently, facts of importance in breeding for resistance. In the Pacific Northwest the most troublesome cause of apple storage decay is a common blue mold often picked up by contact with contaminated lug boxes. The Washington station found that keeping the boxes in streaming steam for 2 minutes would kill the rot spores.

Bacterial fire blight is destructive to apple trees and particularly to pears. The Iowa station reports that treatment of young cankers on apple with a special zinc chloride solution along with bordeaux spray during bloom was beneficial when blight was serious. Colonies of bees used in an infected orchard did not transfer blight if moved to a clean orchard before spring. New pears markedly resistant to blight have been developed at the New York State station, four of Seckel type and six of Bartlett type, planting stocks of some being available although their adaptability to other regions is still to be determined. The station tested 359 seedlings derived from 11 Kieffer hybrids and found those resulting from Kieffer \times Phelps the most resistant. The New York (Cornell) station found that fire blight ooze, if kept dry, might remain infective for 2 years though only 2 weeks if not allowed to dry. The structure and composition of shoots of plants resistant or susceptible to fire blight were compared at the California station. The size of intercellular spaces appeared unimportant but high nitrogen content was usually associated with susceptibility.

Virus diseases are being recognized as of consequence even in apple and pear orchards. The New York (Cornell) station, observing a form of apple mosaic in two orchards for 5 years, found the infection to increase over 51 percent in one and over 69 percent in the other. The evidence pointed to pruning operations as more effective than

insects in its spread. The Oregon station demonstrated the virus nature of the stony pit trouble of Bosc and Anjou pear trees, characterized by bark roughening and abnormal leaf symptoms. It was transmitted by budding, the symptoms generally appearing the second season after. Bartlett failed to show typical symptoms. The California station found this type of trouble on Bosc and Hardy varieties transmissible by grafting.

The Western Washington station reported the results of preliminary studies on the overwintering of two Pacific coast brown rot diseases of stone fruits (*Sclerotinia laxa* and *S. fructicola*) which will help improve the effectiveness of preventive measures. Important is the finding of this station that calcium cyanamide, pulverized and oiled, when applied with a knapsack duster to the soil surface in prune orchards in March prevented the development of the spore-cup stage of the more widespread form by which the disease chiefly survives in that section, and at the same time reduced the emergence of the serious insect pest, thrips, to about one-tenth that in untreated plats. The California station reported for the *laxa* species, cause of serious blossom and twig damage to apricot and almond, that an eradicant spray of monocalcium arsenite and oil prevented spore formation and spore germination on old twigs and fruits and reduced blossom blight by 70 to 80 percent. Other arsenites were also helpful but showed danger of injury if applied too late. If future tests confirm the preliminary results, such sprays, applied conveniently during the winter, may eventually replace the present bordeaux blossom spray which must be precisely timed for effective results. For the control of the common (*fructicola*) brown rot and also scab on peach fruit, preliminary trials by the Virginia station gave promise that bordeaux mixture may be safely used if arsenical injury is prevented by adding of zinc-lime.

The California station, endeavoring to find some effective point of attack against bacterial canker (*Phytophthora cerasi*), made a careful study of its behavior and manifestations on leaves, buds, blossoms, fruits, green shoots, and limbs of cherry, apricot, and plum. What appears to be the same trouble was discovered in 1938 by the New York State station in sweet cherry trees in the Hudson River Valley and later found in western New York and Pennsylvania, Windsor being the most resistant and Giant the most susceptible of the varieties studied. Trees 12 to 15 feet high were killed to the ground during a single dormant season. In two orchards over 60 percent damage was reported. The peach bacterial spot is another destructive disease. Of interest is the evidence of the Delaware station that it may be controlled under dry conditions, that it is carried over in terminal buds, and is greatly aggravated by the presence of chicken manure.

The most generally damaging eastern cherry disease is the leaf spot (*Coccomyces*) which overwinters in dead leaves. The West Virginia station studied the time of spore discharge and found that for effective prevention it was necessary to spray both before blossoming and after the fruit was picked, not merely while the fruit was forming. The Michigan station reported that 1938 tests, confirming 1937 results, indicated inadequate control of leaf spot by lime-sulfur, a tendency to fruit dwarfing by bordeaux, and severe leaf injury by Cupro K. Most promising for good control without injury was a

four-spray program of Basicop with zinc sulfate and lime. The Ohio station obtained better control with uninjured foliage from fixed copper sprays than from lime-sulfur. On the Pacific coast a rust fungus (*Tranzschelia*) attacks a number of the stone fruits. That more than one variety of this fungus exists was discovered by the California station in studies basic to better control.

The peach mosaic disease, against which a national eradication campaign is being conducted, is the subject of study by the California station where three distinct peach viruses beside the mosaic have been reported, asteroid spot, mild mosaic, and infectious variegation. This station also found the peach mosaic problem complicated by the fact that almond, apricot, plum, and prune harbor viruses that act like mosaic when transferred to peach. Furthermore, the Colorado station proved that certain varieties of peaches may carry mosaic without showing symptoms and that aphids may transmit the disease. In continued study by the Connecticut (State) station on the destructive "X" virus of peach, discovered by it in 1933, the number of infected orchards was found increasing with more severe damage sustained each year. Diseased peaches had never been found except in proximity to diseased chokecherry trees, suspected of being the chief hosts responsible for its spread.

In citrus-disease research, the California station found that the chief means of transmission of psorosis or scaly bark disease is through budding from diseased trees. Several strains of the virus were found and leaf symptoms discovered which permit early detection and removal of affected trees. This work has led to a voluntary system of registration under the State Department of Agriculture of tested disease-free trees which, if used by nurserymen as a source of budwood, will serve to prevent distribution of the disease in nursery stock.

In continued work with various fungicides, the cupric ion was found by the California station so effective against the fungus causing citrus gummosis and brown rot, killing swarm spores of the fungus at $3\frac{1}{3}$ parts per million, that it was possible to obtain protection with 1 pound of copper sulfate and 1 pound of lime to 100 gallons of water, a dilution so weak as to avoid most injury from subsequent cyanide fumigation. Inoculation tests proved lemon, sweet orange, sour orange, and Rangpur lime fruits very susceptible to this brown rot; King mandarin, Owari satsuma, and Severinia less susceptible; most of the citranges, Yusu orange, citrangequat, Balsamocitrus, and Sampson tangelo highly resistant; and yellow sour limes and three kinds of sweet limes practically immune. Trunk resistance, however, was not always in line with fruit resistance. The Florida station reported continued success in dealing with both gummosis and psorosis on grapefruit trees by bark scraping if done thoroughly and in the early stages.

Work by the Florida station on melanose of citrus fruit due to *Phomopsis* indicated the impossibility of complete elimination but showed that avoidance of any tree-weakening factor was an aid in connection with control by pruning and spraying. That gas attacks through the soil may prove useful against the destructive *Armillaria* root rot of orchard trees is indicated by exploratory tests by the California station with injections of carbon bisulfide at different depths

down to 10 feet. The diffusion of the gas was rapid, the kill of the fungus slow, requiring weeks and even months at the deeper levels. It appeared that under average conditions properly spaced injections 8 inches deep in late spring or early summer, the soil surface being sealed with irrigation water, were able to kill the fungus in tree roots to a depth of nearly 6 feet.

The California station, working on factors contributing to spoilage of dates, derived data indicating that tannins may possibly impede the organism involved after it has gotten through the fruit skin. Management of the ripening fruit bunches to promote aeration and protection from moisture by the use of special bags or covers were found essential to the avoidance of fruit rot. Four of 22 fungi found were especially common causes of date spoilage in California. Two species of *Omphalia* mushrooms were found capable of causing date palm root rot. The Arizona station proved that 2 species of *Fusarium* are responsible for blight of the date-flower clusters. Besides early-season spraying, the removal of stamen-bearing clusters after pollination and fruit-bearing structures after harvest were beneficial.

Olive-knot bacterial infections were found by the California station rarely to occur before leaf fall and never more than 9 days thereafter due to the scar-healing processes. The same station found that olive roots may be infested, with only superficial bark injury, by the nematode *Pratylenchus musicola* which also produces a root rot in figs. Proof of mechanical transmission of a disease of papaya studied by the Hawaii station indicated its probable virus nature.

The quality of Persian (English) walnuts was found by the California station to suffer from the effects of bordeaux mixture injury, which sometimes occurs when this material is used against bacterial blight. This difficulty may disappear if copper oxalate can be substituted for bordeaux. Such seems probable from the results of a 4-year trial by the Oregon station and the Department (B.P.I.) in which copper oxalate gave very effective protection without foliage injury under Oregon conditions. Bordeaux mixture, however, except for occasional injury, produced satisfactory results in these tests. The same station, conducting cooperative work on the destructive bacterial blight of filberts which caused estimated losses in 1937 of up to 35 percent of the trees in young orchards and up to 25 percent of the nut crop in older orchards, reported that the incidence of bud and twig blight in bearing groves in western Oregon could be reduced to a mere trace by three applications of bordeaux mixture applied in late summer, late fall, and early spring. No effective means of control had previously been worked out.

ORCHARD INSECTS

Of all the major orchard insect pests none is probably harder to deal with than the common apple worm or codling moth. Active work has aimed to develop more effective spray materials, less toxic to man than lead arsenate, as well as supplementary control measures. The New York State station reports satisfactory control with a commercial nicotine preparation, Black Leaf 155, when applied at least every 10 days. Three cover sprays left negligible residue and

five or six but light residue. This was less conspicuous when oil was used. Oil, however, could not be followed by sulfur without danger of leaf drop. A tank-mixed nicotine-bentonite spray also gave good control but left a heavy deposit readily removed, however, with a brush cleaner. That such fixed nicotine compounds are actually more poisonous to newly hatched codling moth worms than materials with more available nicotine was a valuable discovery of the New York (Cornell) station. The New Jersey station also found nicotine-bentonite sprays effective although more expensive and more difficult to remove than oil-lead arsenate, a difficulty lessened where oil-nicotine sprays followed. Working with lead arsenate spray, the Delaware station found rosin-residue emulsion both a safe and an effective sticker and spreader. The Pennsylvania station studied the chemical changes resulting from adding lead arsenate to lime-sulfur sprays. The conditions under which nicotine sulfate is effective against codling moth eggs was investigated for 3 years by the Virginia station. Fixed nicotine preparations were not effective against eggs of any age. Free nicotine or nicotine sulfate effectively killed moths and nicotine with summer oil and lead arsenate when used against the first brood in May and June gave good protection in the Virginia experiments without later sprays. In experiments for 3 years with β -naphthol-treated tree bands for supplementary codling moth control, all bands with three-tenths of an ounce per foot were satisfactory. Encouraging results were also reported by the same station with several materials used in bait traps set in orchards to capture flying moths at egg-laying times. Fixed nicotine preparations, particularly when used with oils, compared favorably with lead arsenate for worm control in 2 years' tests by the Michigan station, and the apple trees proved remarkably tolerant. In studying lights for attracting moths to traps, the Indiana station found dark-blue 200-watt tungsten filament electric lamps the most generally effective of all lamps tested.

Work at the Illinois station with the Department (B.E. and P.Q.) on nicotine-bentonite substitutes demonstrated that although more expensive, the degree of effectiveness and the simplification of the washing problem usually offset the extra cost. The Missouri station, too, obtained good protection from codling moth with fixed nicotine preparations. Neither Black Leaf 155 nor dry-mix nicotine-bentonite left very noticeable residue. The local egg-laying response of codling moths to temperature was studied by the Arkansas station. The moths laid 90 percent of their eggs in the first 7 days in midsummer as compared with 12 days in the spring. The greatest number of eggs was deposited at 77° F. Temperatures as high as 86° checked reproduction and shortened the life of the moths. In 5 years of work, lead arsenate, either with or without summer oil emulsion, was more effective against codling moth than other arsenicals or organic spray materials tried by the Kansas station. Recent work at the New Mexico station revealed three kinds of bacteria thought to be mainly responsible for the high attractiveness of molasses baits by producing esters of acetic, benzoic, and malonic acids and ethyl, methyl, and higher alcohols related to acetyl methyl carbinol.

The Washington station reported additional successful work on the "inverted" or "dynamite" type of spray. California station tests in

1938 also demonstrated its effectiveness, even with increasing moth populations, wherever properly timed during heavy flights of the first brood. The California station likewise proved the value of electrocuting light traps with high-wattage blue bulbs in cutting down the heavy spring flight of moths emerging from packing sheds. An interesting recent development was reported by the Washington station in which, by using a wetting or emulsifying agent, a powdered insecticide with oil, made into a creamy, flowable paste with water, is injected by a special device into the regular spray-pump intake in proper proportion and is then dispersed under pressure by spray-gun nozzles into fine droplets that adhere to sprayed surfaces with very little run-off and much more effectively than the usual spray mixtures. Application by means of the spray injector of insecticides which do not form a stable dispersion in water, was found to be more economical and efficient than conventional procedures, and to utilize the full principles of inversion with increased dosage.

The Virginia station conducted experiments for 3 years to determine the relative susceptibility of 20 apple varieties to the woolly aphid. Only 2, Northern Spy and Early Harvest, were highly root-resistant. Excellent control of the rosy apple aphid was obtained by dormant spraying with tar oil or petroleum oil containing dinitro-*o*-cyclohexylphenol dissolved in oil or used as a wettable powder in diluted oil emulsions. Good control also resulted from delayed dormant applications of 3 percent of petroleum oil and 0.4 percent of tar oil. The same station showed that the white apple leafhopper is usually abundant only in sprayed orchards. Evidence was obtained that lime-sulfur and bordeaux spray hold in check a fungus that in some seasons kills out the leafhoppers to a large extent. The New York State station, in studies of the natural insect enemies of the leafhoppers, learned facts that should help in timing sprays so as to interfere as little as possible with these beneficial parasites.

The European red mite attacks apple and pear, stone fruits, and citrus fruits. The Virginia station contributed useful information about its local life cycle and obtained good control by late dormant spraying with petroleum oil alone or in combination with tar distillate, nicotine sulfate, or dinitro-*o*-cyclohexylphenol. Both mites and eggs were killed effectively in summer with Ortho-K oil emulsion. The New Jersey station found an emulsion of 3 percent of petroleum oil and 2.5 percent of neutral tar oil effective against both the red mite and apple aphids without observable injury or bud retardation. According to the New York State station, the eye-spotted budmoth was controlled effectively in western New York with a 3-percent concentration of a mixture of 4 parts of dinitro-*o*-cyclohexylphenol and 96 percent of lubricating oil. Of eight materials tested against the plum curculio, best control was obtained by lead arsenate, 3 pounds to 100 gallons, applied three times after petal fall. The Kansas station found that the unspotted tentiform leaf miner can be controlled by a nicotine sulfate-oil emulsion summer spray applied in the last four cover sprays for the codling moth.

Among the introduced pests which have threatened American orchards, the oriental fruit moth from Japan is showing greatly reduced numbers in infested areas into which experiment stations with the help of the Department (B.E. and P.Q.) have introduced parasitic insects. The New Jersey station reported that peach in-

festation by the moth was greatly lessened where extensive parasitism has occurred. It continued liberating two kinds of parasites in orchards that showed heavy infestation the previous year. The Ohio station found that these moths had been reduced to economic insignificance in the principal peach belt by introduced parasites, the most effective being *Macrocentrus ancylivorus*. The New York State station also attributed to parasites a large part in decreasing damage from oriental moth, *Macrocentrus* being responsible for 90 percent of the parasitism. The Virginia station, testing for 3 years the efficacy of bait traps in reducing these moths, found the insects caught in largest number by a bait solution of 1 part lignin pitch to 20 parts of water with about 1 part per thousand of terpinyl acetate added, a chemical which the Pennsylvania station had reported as outstanding among 40 tested. For 9 years the Illinois station tested oil dusts for the control of the moth in southern Illinois, four applications of oil dust (sulfur, hydrated lime, talc, and oil) being found most effective when given during the last 3 weeks before picking.

The peach tree borer was found by the Virginia station to be better controlled by fall than by spring treatments with paradichlorobenzene, spraying the chemical dissolved in oil usually being a little more effective than applying the crystals in a ring about the tree base, but at almost double the cost. The Colorado station, by treating 10-year-old cherry trees with this chemical for the same pest, obtained 100-percent control at a cost of 2 cents a tree. According to the New York State and the Illinois stations cooperating with the Department (B.E. and P.Q.), ethylene dichloride, used as an emulsion in water, has advantages for borer control over paradichlorobenzene in that it will not injure young peach trees, is effective in colder weather, and costs less than the other material.

The troublesome plum curculio was found by the Maryland station to enter orchards only after the mean daily temperatures reached 55° F. or above. It succumbed to arsenical sprays much more readily than to arsenical dusts, three spring sprays being recommended, along with burning of woodland and fence rows nearby, to kill the overwintering insects, and soil cultivation between July 8 and 18 to kill the pupae. The Oregon station reported that through controlling thrips by either a lime-sulfur-nicotine sulfate spray or nicotine sulfate with miscible-oil emulsion, yields of experimentally sprayed prune trees were increased by from 62 to 4,000 percent. A puzzling problem of insect identity was solved when the California station found that the European fruit lecanium feeding on different hosts has distinctly different shapes.

The filbert moth, the most important pest of this nut in the Pacific Northwest, was reduced in Oregon station tests from 23-percent nut infestation to less than 1 percent by the use of lead arsenate, 3 pounds to 100 gallons with spreader, the best of 20 different spray combinations tested. *Trichogramma evanescens*, an egg parasite, was particularly effective in holding the pest in check.

A large proportion of the \$4,000,000 spent for citrus-pest control is said to be applied in fighting red mite. The California station, over a 3-year period, worked out a more satisfactory mode of control than the usual spray methods in the form of a dust composed of dinitro-*o*-cyclohexylphenol diluted with walnut-shell flour, a byproduct of the

walnut industry also developed by the station. In 1938 more than 400 tons of this material were applied by growers in southern California. For the control of mites on citrus and grapes this station also developed a spray made by dissolving selenium in potassium ammonium sulfide which appears harmless to the trees or vines and has produced fruit injury only to a limited extent in certain districts. Properly used, this spray on citrus or grapes was reported to present no public health hazard. In vineyards, however, long-continued use of selenium is held undesirable. The station uncovered the presence in five southern California counties of a new kind of bud mite attacking citrus trees, occurring most abundantly on lemon. Ordinary hydrocyanic acid gas fumigation or oil sprays as used for other pests were found very effective against this pest.

A description has been published of dusting equipment developed by the California station for the control of citrus pests. Different types of spray guns for different types of grapefruit trees were tested by the Florida station as to their comparative merits for use with oils for the control of purple scale. The heaviest leaf infestation was found near the tops and inside centers of the trees and on the under sides of the leaves. Difficulty in controlling scale insects in certain districts of California by the fumigation methods commonly and successfully employed elsewhere was found by the California station to be due to the presence of races of the California red scale, the black scale, and the citracola scale which are more resistant or tolerant toward hydrocyanic acid than races from other sections. A difference in tolerance, at least in the California red scale, was shown with respect to other fumigants including methyl bromide and ethylene oxide. The discovery that doses of hydrocyanic acid gas not strong enough to kill the California red scale will stupefy and cause an unusually high proportion to survive later killing doses shows the importance of research work in insuring maximum success in control.

The orange tortrix, a small moth, recently became prevalent in many districts of California. The California station investigated its life habits as well as defensive methods against it. Large numbers of chemicals were tested in the laboratory over 4 years and cuprous cyanide gave promise of being a satisfactory substitute for cryolite or barium fluosilicate in its control. Pyrethrum-talc dust also produced a high kill of the larvae. A lemon pest recently of considerable importance is the citrus thrips for which the California station has found sulfur efficacious.

SMALL-FRUIT DISEASES

Studying the nematode disease of strawberries, the Massachusetts station found that in plantings on Cape Cod and in North Carolina, in each case with infestations from both regions, the symptoms were always characteristic of the region from which the nematodes originated rather than of that in which the plants were grown. The names "spring dwarf" and "summer dwarf" were proposed for the diseases caused, respectively, by the Cape Cod and southern types of the strawberry nematode (*Aphelenchoides fragariae*).

The destructive and rapidly spreading red stele root rot of strawberries, first recorded for the United States in 1935, has been under

intensive study by the New Jersey station, which reports that the only named varieties thus far proven resistant are Aberdeen, Mastodon, and Pathfinder, only the last being suitable for general commercial planting in New Jersey. Among New Jersey selections tested for susceptibility in 1939, however, at least 10 proved to be resistant. Almost half of the seedlings tested which had Aberdeen as one parent have shown resistance. Production of these resistant strains is expected to prove of great significance for the strawberry industry. Besides tests of 4 resistant Scotch selections, the Illinois station reported the discovery of a red stele-immune variety, which is being crossed with others to secure resistant selections qualifying for the various commercial requirements.

Crown gall on raspberries, according to work by the Ohio station, may be eliminated by propagating from the buds. By this method several varieties are reported to have been recently brought back into production.

The virus diseases of raspberries have received attention in a number of States. The New York State station reports the development of the new markedly resistant Marcy raspberry. The Washington station reports raspberry mosaic to be gradually spreading to new localities and to have become of major importance in western Washington. The aphid responsible for transmitting this virus fails to reproduce on several raspberry varieties, and tests indicated that resistance to the vector is inherited, the mode of inheritance having been worked out on the mosaic-escaping Lloyd George variety. Greenhouse testing was found to be a convenient and rapid method of determining the relative susceptibility of red raspberries to the aphid vector. The Ohio station found methods of roguing out virus diseases of raspberries to be effective in producing disease-free plantings. Physiological studies by the Michigan station have indicated significant differences between normal and mosaic raspberry plants in their contents of sugars, starches, nitrogenous substances, and ash, and also in their photosynthetic, respiratory, and transpiration activities.

A new red currant mosaic virus disease in the Hudson River Valley has been described by the New York (Cornell) station. The more advanced stages are marked by stunting and by decline in vigor and fruitfulness, resulting in dieback and final death of the plants. Transmission was effected by grafting. The Michigan station reports evidence of the resistance of the Prince Albert currant to anthracnose (*Pseudopeziza ribis*), which severely defoliated the variety Wilder.

A disease of grapevines closely resembling the disastrous California vine disease of the nineties, under investigation by the California station, causes serious losses in several grape varieties in the San Joaquin Valley, killing the vines and spreading rapidly. It has been found transmissible by bud and root grafts. The Texas station reports that a start has been made on commercial vinifera grape production in the southern part of the State, as a result of field tests and work on rootstocks resistant to the cotton root rot fungus. Both Dog Ridge and La Pryor (a selection of a local wild grape) varieties are reported to have proven satisfactory in solving this important problem.

Root knot nematode injury to pineapple plants has been found by the Hawaiian Pineapple Producers' station to be greatly restricted by a predatory species of fungus (*Dactylella ellipsozona*), while several others have proven capable of reducing the nematode injury to a considerable extent.

SMALL-FRUIT INSECTS

The strawberry leaf roller is reported by the Kansas station to have caused serious damage to commercial plantings in the northeastern part of the State. It was found that eggs of the first generation are laid on the first leaves, and that for a week or more after hatching the larvae work beneath a light webbing before rolling the leaves and thus preventing access of metallic insecticides. Of the many organic materials tested against first-generation larvae, nicotine sulfate in a summer emulsion oil applied three times between first hatch and rolling of the leaves is said to have given over 90-percent control, while pyrethrum dust gave similar control after the leaves were rolled. Good control of first- to third-generation larvae in new fields was obtained with lead arsenate or cryolite. Use of cryolite (either natural or synthetic) is also reported by the Ohio station to have proven effective against this pest, three applications at weekly intervals having largely suppressed the activities of one brood. Dry Pyrocid dust may be substituted in the application immediately preceding harvest. Even where early-season damage was serious, a vigorous postseason program of fluorine dust or spray treatments afforded effective control. The Kentucky station recently summarized several years' work with the strawberry crown borer, said to have been the worst pest of this crop for the past 40 years. In this State two generations occur on the ubiquitous common cinquefoil. Much of the borer infestation in strawberry patches has been traced to this weed. Several insect parasites and predators of the crown borer have been found. Two burrowing webworms are reported by the Virginia Truck station as new and serious pests of strawberries in that State, and two parasitic species of flies have been reared from them.

The Massachusetts station has found dusting with materials containing rotenone as effective as spraying for control of the destructive cranberry fruitworm. This is said to be particularly gratifying in view of the general preference among growers for dusts. Lead arsenate residues on the fruit or vines were satisfactorily reduced by a few days' flooding, a discovery which may have considerable long-range value.

Five years' experiments with insect-electrocuting light traps in a number of grape-growing centers were found by the California station to hold promise for satisfactory control of the grape leafhopper, said to be the major pest on 300,000 of the State's 500,000 acres of vineyards. Not only has this method proved effective, but its cost is small in proportion to that of normal control otherwise. While results are somewhat variable, due to differing conditions, the lights have proved generally more effective than other means of control.

ORNAMENTAL-PLANT DISEASES

Two comparatively new gladiolus diseases were reported on by the Michigan station, one a *Fusarium* yellows disease, with discussion of the progress attained in segregating the resistant and susceptible

varieties, and the other a basal dry rot due to another *Fusarium*, with description and suggested control measures. The latter is said to be increasing in commercial gladiolus stocks. The Pennsylvania station calls attention to a smut disease of gladiolus believed to be the first report of *Urocystis gladioli* in the United States and on which culture studies are described.

A bud and twig blight of azaleas due to *Sporocybe azaleae* and said to be threatening extermination of some species of cultivated and native azaleas in the State has been investigated by the Massachusetts station, which describes the fungus and symptoms induced. Nine azalea and rhododendron species were inoculated, the latter proving resistant. The disease was controlled by pruning and destroying infected materials, and also by spraying or dusting with copper fungicides.

A stem rot disease of geranium cuttings is described by the Massachusetts station as causing considerable losses to florists. Culture conditions, synthetic root-promoting substances, or fungicides failed to reduce the losses, and high temperatures were found to favor the malady. Stock plants grown under glass consistently gave a higher percentage of disease-free cuttings than field-grown plants. As a means of control it is therefore recommended that stock plants be grown under glass.

The Massachusetts station also studied a chlorosis of gardenias found to be induced by soil temperatures of 64° F. or less. The intensity of the disease was heightened with lowering of temperature and a sharp rise of temperature maintained for 13 days proved sufficient to initiate a gradual return to normal green color. Attention is called by the New Jersey station to a new disease of gardenias, preliminary studies indicating it to be of bacterial origin and to present a serious menace to the growing of this ornamental under glass. With respect to the *Phomopsis* canker of gardenies, this station found that the fungus starts at the nodes on the base of the cuttings after they have been set in the rooting medium. The practice of removing the lower leaves with a knife before embedding the cuttings furnishes an excellent point of entrance for the parasite through the freshly cut surfaces.

For sterilizing soil for sweet peas, the Ohio station found no striking differences in effect between steam and hot water, provided subsequent leaching was practiced to remove the accumulated soluble salts. The advantages of steam lay in the shorter time required to treat and plant afterwards and in the more effective control of bacterial and fungus diseases.

The incidence of a *Verticillium* disease of chrysanthemums described by the Ohio station was found to be greatly decreased by removing diseased plants and selecting the more vigorous individuals for propagation. Varieties of the different types were grouped according to susceptibility and resistance.

The Colorado station found 3 species of *Fusarium*, including 20 strains, to be the cause of carnation root rot—a disease previously ascribed to 1 species.

Since roses are among the most important ornamental plants of the United States, their diseases and pests are of very considerable interest and demand much attention. The Texas station found that rapid peduncle abscission reduces the incidence of dieback in roses,

and factors tending to provide a rapid supply of food elements to the region increase this process. Of the fungicides tested, a mixture of sulfur, red copper oxide, and calcium arsenate as a dust gave the best control of both dieback and black spot of roses. Working with black spot, said to be serious in most commercial rose houses, the New York (Cornell) station found it to attack all greenhouse varieties under favorable conditions, some more than others. The fungus was found to be carried over in leaves between seasons, while dissemination in the houses was accomplished mainly by splashing water. Syringing for red spider mites greatly facilitated spread and severity of attack under glass, and the substitution of pyrethrum-rotenone or a selenium-containing spray proved effective in control. Dusting sulfur was partly successful as a preventive.

Studies by the same station of rose powdery mildew indicated that high germination of the fungus spores and preservation of germinability depend on conditions of humidity. Germination was better on young than on old leaves, and lower surfaces were slightly more favorable than upper. Relative humidity at the leaf surface, especially of young leaves, was very high even in a seemingly dry atmosphere.

Narcissus mosaic was reported by the New York (Cornell) station to be widely distributed and responsible for producing low-grade flowers and small inferior bulbs. The virus is transmitted by bulb grafts, mechanical inoculation of infected leaf sap, and propagation by mosaic affected bulb stock, but probably not by soil contamination, root contact, or through the seed. Transmission by root mutilation or by cutting or picking the flowers is said to be negligible. Intervarietal inoculations indicate the malady to be probably due to a single virus, and plants other than narcissus appear to be highly resistant or immune. Thus the most satisfactory control method is to remove and destroy affected plants and to protect healthy ones by cheesecloth cages. The Oregon station states that the control of certain narcissus troubles by bulb treatment has forestalled the danger of extinction of this important commercial industry. This method, developed by the station with the Department (B.P.I.), is said to be used now throughout the United States.

The Oregon station found that tulip breaking (mosaic) results from the interaction of tulip virus 1, which inhibits flower and leaf color, and tulip virus 2, which adds flower color but has no visible effect on chlorophyll distribution. The established "broken" tulips contain physiologically balanced mixtures of these two viruses. Of 49 varieties studied, all dark-red varieties of the new tulip race Mendel were found to have a blue epidermal pigment in common with other varieties exhibiting the peculiarity of darkening ("selfing") when inoculated with tulip virus 1. By inoculation the type of "break" to be expected was determined. The probability that blue-based varieties will "self" may be of real help toward complete elimination of virus-infected bulbs.

An anthracnose disease of *Lippia lanceolata* has been shown by the Indiana station to be caused by a new species of fungus (*Sphaceloma lippiae*), which is described and compared to a somewhat similar disease of mint. The station also described a stem rot of campion (*Lychnis viscaria*) due to a form of *Phytophthora cactorum* differing in pathogenicity from that occurring on apple in the State.

A bacterial (*Phytophthora blight*) leaf spot of tuberous begonia was reported by the California station as occurring in lath-house nurseries under conditions of high humidity and temperature. Twelve species and varieties proved susceptible. Air humidity and temperature control were recommended for minimizing the injury.

Two diseases of annual stock—mild and severe mosaics—were described by the California station. Prevalent in the cool coastal valleys, they cause considerable loss in the cut-flower and seed crops. They were readily transmitted by plant-juice inoculation and by a species of aphid which breeds on this plant, but seed transmission tests were negative. Ten other kinds of plants were found susceptible to both viruses. Failure to infect some eight members of the mustard family served to differentiate these from other viruses of this host group. A bacterial blight of annual stock, said by the California station to be a limiting factor in seed fields, was shown to be carried with the seed and to be preventable by seed treatment with hot water at 127° F.

ORNAMENTAL-PLANT INSECTS

The ornate aphid, described first on violets in England, was reported by the California station as new to North America, having been found on several host plants, including heliotrope, in that State. Illustrated descriptions were given of the stages of this insect.

For control of gladiolus thrips, the Florida station has reported a poison bait, used in place of paris green and composed of tartar emetic, brown sugar, and water, as proving very effective and perfectly safe.

Selenium incorporated in the soil is said by the Ohio station to have given excellent control of red spiders infesting carnations. When used in nutrient solutions it was not so effective with carnations, but gave satisfactory control of red spiders on tomatoes and roses, as well as of the black chrysanthemum aphid on this host plant.

Experiments conducted over a period of years by the Oregon station have shown that the green peach and potato aphids and apparently a third are vectors of the two viruses of tulip breaking (mosaic).

Tests are reported by the Oklahoma station for the control of poinsettia root aphid, which first attracted attention in 1937 infesting practically mature greenhouse plants. Dusting the earth ball and inside of the pot with a 5-percent nicotine dust gave good control with but little root injury. Loosening the earth ball and submerging it in a solution of Black Leaf 40, soap, and water previously heated to 110° F. also proved effective.

In laboratory tests by the New Jersey station, derris powder proved considerably less effective than pyrethrum powder and Dry Pyrocidine in controlling the orchid weevil. However, all gave an excellent kill when applied as they would be in the greenhouse. It is pointed out that these insecticides are inexpensive, easy of application, and less objectionable than the paradichlorobenzene treatment, and at the same time unlikely to cause injury to the plants or the peat in which they are grown.

TREE DISEASES

Recent investigations of elm tree diseases have been reported by various stations. Continuing its studies of the relation of insects to

the Dutch elm disease, the New York (Cornell) station has found that infested elm borers (*Saperda tridentata*) are more effective in initiating the disease than direct atomizing of wounds with fungus spores. The Ohio station, cooperating with the Department (B.P.I.), reports an epidemic dying of American elms which has occurred for several years in the Ohio River watershed. The typical discoloration of the inner bark preceding death of the larger roots is responsible for the name "phloem necrosis" applied to this virulent and rapidly spreading disease. Though over 4,000 attempted isolations have been made, no evidence of bacterial or fungus relations has been found, and this and other data favor the view that the disease is systemic and of virus origin.

As a result of a study of the prevalence of wilt diseases in maple and elm trees, the Michigan station reports four species of fungi as capable of inducing a wilting and dying back of the branches of elms, one only of which proved infectious also to maples. Symptoms somewhat resembling these but due to nonparasitic causes are also noted and control measures for the various troubles are outlined.

Diseases of coniferous trees have also received considerable attention. Investigations by the Wisconsin station have suggested that the damping-off fungi prevalent in certain calcareous soils limit the distribution of some species of pines to such an extent that the advisability of extensive plantings of northern conifers on heavy calcareous soils is questioned. Wound inoculations made at the California Citrus station with the fungus *Coryneum cardinale*, which causes cankering and death to Monterey cypress trees, induced lesions of considerable size on 13 other species of this group. Other conifers found susceptible were incense cedar and 3 species each of arborvitae and juniper. Pecky cypress, used for reproductions of antiques and interior finishes, was reported by the Florida station to be caused by the fungus *Fomes geotropus*, which was also found on several deciduous species. Berckman blight is said by the Oregon station to have threatened the marketability of this variety of arborvitae so widely used in landscape gardening. A species of *Coryneum* was found to be the cause of this disease of American arborvitae and its horticultural varieties, and a general method of control was developed. The Indiana station reported a new species of needle rust fungus (*Coleosporium crowellii*) parasitic on limber and piñon pines.

The fungi causing wood decay are often difficult to identify. The Pennsylvania station with the Department (B.P.I.) has found that growing them on media containing gallic or tannic acids often gives variations that help in distinguishing them. A considerable number of species were thus separated into 10 different growth and reaction groups. Continuing its studies of the effect of chemicals on the rate of decay by wood-destroying fungi, the Minnesota station found that dextrose alone or with asparagine increased the rate with some and decreased it with other fungi. This station showed that three wood-rotting fungi growing in Norway pine blocks remained alive after more than 38 weeks' immersion in water, while another species was killed in about 6 weeks. All such data should aid in working out better means of preventing the many types of rot incident in lumber and wood products.

Researches on miscellaneous tree diseases resulted in finding a new stage of the fungus *Hypoxyylon pruinaum* causing a destructive canker of forest poplars and in working out the causes of rough, fissured bark in quaking aspen, both by the Minnesota station; in determining how the catkin-deforming fungus *Taphrina* of the common alder overwinters, by the New York (Cornell) station; in evidence that primary cankers on seedlings of the common locust tree are due to frost injury followed by fungus invasion, by the Iowa station; and in data on a fungus leaf blight of hawthorns, found by the New Jersey station to be generally distributed in that State.

The Florida station has found tung tree seedlings to be highly susceptible to the root knot nematode during their first year in the nursery, but very resistant, if not immune, when planted in the field at 1 year of age or older. Severely affected seedlings when transferred to the field showed no further infestation and eventually outgrew all root symptoms. However, early attack was said to bring lowered vigor with danger of death by low temperatures.

TREE INSECTS

Based on its work at the State Dutch elm disease laboratory, the New York (Cornell) station has published an account of the biology, habits, and distribution of the bark beetle *Scolytus sulcatus*. Though apparently its favorite host is the apple, it frequently breeds in elms and has been recorded from plum trees. Twig feeding on elms was found to be of primary importance in transmission of the Dutch elm disease. Both this and the Connecticut (State) station have presented the results of studies on the life history and habits of the native elm bark beetle (*Hylurgopinus rufipes*), also a spreader of the disease. The control of cankerworms on roadside and ornamental plantings of elms has been worked out by the Michigan station. The fall cankerworm is said to present no difficulty where the dormant oil spray for European elm scale has been applied, and when this treatment is immediately followed by banding of the trunks attack by the spring cankerworm is also prevented. For general purposes lead arsenate with an oil spreader-sticker is said to have proved satisfactory.

With regard to insect pests of coniferous trees, the New York State station found strawberry root weevils to be particularly troublesome in some nursery plantings of the State and to occur also on many other hosts. Its characteristics and seasonal history, the injuries caused, and control measures were reported upon. The same station also presented the results of spray tests with oils and with nicotine sulfate as holding great promise for the control of the pine needle scale. The Connecticut (State) station reports derris or cube root as more effective than lead arsenate sprays in reducing injuries to red pine by the European pine shoot moth. The seasonal history and habits of the insect were also studied. Three new forms of western conifer aphids were described by the Utah station, and an annotated list of the insects, mostly beetles, associated with Jeffrey pine in Lassen National Forest was presented by the California station.

Studies of miscellaneous tree pests include trials by the California station with rotenone-extract dusts, which proved effective in controlling the snowy tree cricket. Dusts containing oil proved more

effective than those without, probably because the oil extracts the rotenone from the particles of ground root and brings them to the surface. Studies by the Virginia station of the severe injury to common locust trees by the locust leaf miner in many parts of that State showed that two early applications of lead arsenate prevented feeding and egg laying by the adult. The same station presented data on the holly leaf miner, an insect of European origin known to occur now from Alabama to Alaska. Parasitism of this pest was found to range from 18 to 54 percent, the most important of four species reared being *Opius striativentris*.

MISCELLANEOUS DISEASES

Progress in fundamental studies of the nature of the plant-infecting viruses has been reported from several States. A special investigation by the Illinois station of a virus disease of endive, lettuce, and carrots revealed the trouble to be due to the aster yellows virus, thus opening the way for development of control measures. A detailed study of the horseradish virus complex indicated the presence of at least two virus diseases of this plant. As a result of this work it was found possible to double the yield of horseradish in the large East Saint Louis district devoted to this crop. The Wisconsin station has tested the inactivating effects on various virus extracts of some 35 chemicals selected on the basis of their known diverse modes of toxic action. In many instances the action proved to be specific, so that by treating various mixtures of viruses with the proper chemical it was possible to destroy one virus without eliminating the other, thus permitting the isolation of each component virus. This differential action may become of considerable value in isolating and identifying viruses where other means have proved unsatisfactory. The California station has presented information on the nature of the anatomical modifications induced and on the plant-tissue relations of certain viruses as well as on the classification of viruses. Anatomical studies were deemed likely to contribute much toward elucidating the nature of the relationship between virus and host.

The *Phymatotrichum* or Texas root rot, widely distributed in certain southern areas and attacking a wide range of host plants, has continued to receive attention. According to the Texas station, growth of the fungus in nonstarchy media was inhibited by as little as 1 part per million of copper, while mercury as corrosive sublimate was second in toxicity. On the other hand, zinc and manganese stimulated growth at all strengths tested, and iron and copper were also stimulative at certain concentrations. The fungus grew about 10 times as much in starchy as in nonstarchy media. Investigation by this station with the Department (B.P.I.) of 125 plant species containing alkaloids indicated 83 to fall within the resistant and immune groups, thus suggesting that these substances play an important role in the mechanism of resistance exhibited by some plants. Study of the alkaloids from bloodroot and two species of hollygrape strengthened this supposition. In fact, berberine was found in hollygrape roots 65 times as concentrated as necessary to prevent growth of the fungus. The New Mexico station has confirmed previous reports that soils high in alkali favor damage to trees by root rot, and that certain soil treatments around infected trees and shrubs have proved beneficial.

With respect to the *Rhizoctonia*-induced form of damping-off, the Minnesota station with the Department (B.P.I.) has compared damping-off tests with direct inoculations of underground stems of older plants as a basis for determining and comparing physiological races of the fungus, finding the latter method to give a truer comparative picture. Since *Rhizoctonia* diseases of many crop plants have developed under different conditions throughout the State, the North Carolina station, after making isolations from 11 different crop plants from many localities, obtained at least 15 distinct strains the parasitic behavior of which in some cases was found to be governed by different temperature levels, a discovery believed to explain in part the continued prevalence of *Rhizoctonia* diseases under changing seasonal conditions.

A *Fusarium* root rot was reported by the Puerto Rico Federal station to have been the chief limiting factor in vanilla production in that region. Investigations indicated that the effects of this disease can be considerably minimized by growing vanilla in loose well-drained and aerated soil in areas of abundant and reasonably well-distributed rainfall.

Powdery mildews of peach and rose were shown by the California station to be distinct though both overwinter in infected buds.

The Alabama station, investigating the nature of resistance to the root knot nematode in beans, found that about the same numbers of larvae had entered the seedling rootlets of a resistant variety as they did those of the susceptible kind. The same was true for other plants. Resistant plants, however, formed no giant cells for the nematodes to feed on, leading to the theory that resistance may be due to substances formed by the plant host that counteract the giant-cell-inducing effect of the larval salivary secretions. These results raise the important question whether resistant plants may not be superior as trap crops, due to the fact that as many larvae appear to enter as in susceptible plants but fail to reproduce. This station is engaged also in breeding crops for resistance to root knot.

A great multitude of disease problems affecting all types of plants are under active study, as illustrated in the foregoing. As a typical example of the results, the Oregon station reported that practical control measures have been developed and tested on 44 plant diseases, with limited investigations on many others.

MISCELLANEOUS INSECTS

The Utah station reports that during the past year information has been collected on the occurrence of several thousand insects of the State, many of them not previously known to occur there. Tests by the Florida station, showing that diet deficiency affects the general vitality of insects and the prolificacy of the females, indicate the possibility of a long-range effect of the absorption of various elements on insect populations. Insect increases following fungicidal applications may perhaps often be due more to a physiological change in cell sap than to a destruction of beneficial fungi. The California station reported considerable progress in the detailed study of respiration and excretion in insects, a line of work which should have many practical applications to insect control. The Oregon station noted that the cost of producing crops in that State had been

greatly decreased by the development of effective methods of reducing the losses from such insects as codling moth, prune twig miner, prune borer, blackberry mite, strawberry root weevils, cutworms, walnut aphids, and the cabbage root maggot.

Past experience, according to the Montana station, shows that insect control must enter into long-time agricultural planning, along with soil and water conservation, agricultural adjustment, crop and range management, and other factors of major importance to this State. Responsibility for assistance in the control of injurious insects is placed on all owners of agricultural and other lands on which insects may breed, whether these lands are idle or in use. In further studies on the Mormon cricket this station found sodium arsenite dusts effective for control when applied either as purely contact poisons or as stomach and contact poisons combined. The Utah station reported that Mormon cricket infestations had been brought completely under control in four counties of the State which had suffered considerable crop damage during the previous 2 years.

At small cost, using half as much lead arsenate as found necessary for treatment of Japanese beetle grubs, tests by the New Jersey station indicated that soil can be so treated that termites apparently will not work in wood buried therein, whereas similar wood buried in untreated soil may be attacked in a few weeks and riddled with termite tunnels.

The Iowa station, which tested 110 inorganic and organic substances as poisons and repellents in grasshopper baits, reported sodium arsenite to be outstanding in the small amount relative to body weight required for high toxicity. The nontoxic substances in baits varied greatly in their effects on bait consumption and feeding time, many being very helpful. Corrosive sublimate was so repellent that little of the bait containing it was eaten. Sodium arsenite and diphenyl appeared to be more toxic to the males than to the females. The Kansas station has found it possible to identify the eggs of 49 common species of midwestern grasshoppers by the appearance of the egg surface, and a key with detailed egg descriptions and photographs has been published. It is expected that this work will be of valuable assistance in the annual fall grasshopper surveys, the results of which furnish the basis for the next year's grasshopper-control program. Through an ecological field survey of grasshoppers in 8 different environments, the Oklahoma station found 17 species sufficiently abundant to cause serious damage. The relative abundance of these dominant species in different situations was studied and 104 species and 12 subspecies or races were listed for the State. The North Dakota station has studied the speed, distance, and direction of grasshopper flight dispersal. Of a large number of marked specimens released, 10 were later recovered at distances of 20 to 215 miles from the starting point. The greatest speed, influenced by winds, was registered by a grasshopper captured 212 miles from the starting point 14 days after release. Records by the Delaware station appear to indicate that great natural barriers, such as the Delaware Bay, are in reality but slight hindrance to grasshopper migration when conditions are favorable to it.

In many sections of New York State, according to the Cornell station, June beetle white grubs (*Phyllophaga*) have caused much

damage to crops such as strawberries, raspberries, upland vegetables, corn, potatoes, melons, and nursery plants, while in other localities they have been confined to pasture and meadow sod lands. Shallow plowing and multiple disking are reported to have given good control in certain sections where the ground was not stony. Insecticides placed about strawberry roots at the time of setting have given promising results, lead arsenate diluted with fine sand having provided good control without injury to the plants. The Kentucky station prepared a field key for identifying 14 species of June beetles known to occur in that State.

Control of wireworms by rotation and other methods is under investigation by the Idaho station with the Department (B.E. and P.Q.). Withholding irrigation from alfalfa fields in one section did not reduce wireworm populations enough to render them safe for potatoes the next season. Plowing under 800 pounds per acre of crude naphthalene in one area in August gave almost a 99-percent reduction in wireworms. Observations in an alfalfa district indicated that the adult females flew high enough to allow considerable dispersal and carried enough eggs to cause some infestation in other fields.

The white fringed beetle (*Naupactus leucoloma*), a native of South America, was discovered by the Florida station in the United States in 1936. Its dangerous character is indicated by the fact that the grubs of this pest were found severely damaging a third of the stand of cotton, fully half that of corn, and a considerable percentage of the stands of velvetbeans and peanuts on one farm in the infested area. They have also been found to attack beans readily, and practically all crops and weeds in infested fields, especially the so-called Mexican clover (*Richardia*). Since the adults, beginning to appear about June 15, are without the power of flight a perpendicular ditch makes an effective barrier, and may serve as a practical control measure. Attention was called to the discovery that only females are produced and to the resulting danger of spread through the transportation of flightless females or grubs.

BIOLOGICAL CONTROL

The use of other living organisms to hold in check noxious insects and disease-producing bacteria and fungi is spoken of as biological control. The scientific development of biological control is beset with many difficulties but each year sees noticeable progress. The effectiveness of parasitic control of the oriental fruit moth in a number of States was referred to in the section on orchard insects. The "milky" bacterial diseases, rather general in the main heavily infested Japanese beetle area, were reported by the New Jersey Station to be without doubt the most important natural means of control encountered, and field tests were under way to determine the practicability of their artificial dissemination. Parasites were introduced from France and Italy by the California station in the hope that they might help destroy apricot brown scale, Mediterranean fig scale, European elm scale, and elm leaf beetle. Another attempt was made to establish the apple woolly aphis parasite (*Aphelinus mali*) and the African parasites of the black scale, although it appeared unlikely that those species, introduced in 1936 and 1937, would successfully control this pest. Studies

on mealybug parasites were also continued. The successful establishment in Puerto Rico of the parasite (*Mirax insularis*) of the coffee leaf miner by the university station leads to the hope that it may become abundant and effective.

In cooperation with the Department (B.E. and P.Q.), the Puerto Rico Federal station continued the introduction of beneficial insects. The Amazon strain of *Metagonistylum minense*, parasitic on the sugarcane moth borer, introduced in 1937, showed promise of establishment in several areas, and a second species of pineapple mealybug parasite (*Anagyrus coccidivorus*) was found definitely established. Encouraging was the extensive attack on palm mealybugs, important avocado pests, a few months after the parasite *Pseudophycus utilis* from Hawaii was liberated on the island. Seven species of coccinellid beetles which feed on scale insects had become established and more were introduced, and the Hawaiian *Collophora inaequalis* showed promise of controlling the yellow sugarcane aphid. To combat the white peach scale, destructive to papaya, a wasplike parasite was introduced from Louisiana.

The saw-toothed grain beetle and the Angoumois grain moth are important storage pests. The Illinois and Minnesota stations worked on insect parasites which attack them. The chief natural enemy of the codling moth in West Virginia was found by the station and the Department (B.E. and P.Q.) to be *Trichogramma*. This is an egg parasite. Chemically treated trunk bands may therefore be used, with a saving in labor, in apple orchards to catch the worms without injuring this beneficial insect. That ants help destroy codling moth worms was also discovered by this station. Infection by a fungus (*Empusa grylli*) was the chief cause of grasshopper death in 1937, according to the Illinois station in studies of grasshopper mortality. The Pennsylvania station reported on six different species of the fungus *Cordyceps* attacking insects in the State.

Although certain soil organisms are known to be antagonistic to a number of plant-disease fungi, little progress has been made in these for artificial control by reason of many complexities and difficulties. The New Jersey station found a strain of *Bacterium simplex* that was able to stop the growth of *Rhizoctonia solani*, a soil fungus that attacks many kinds of plants and causes millions of dollars of loss annually in this country. When a nutritive fluid in which these germs had grown was used to treat greenhouse soil full of *Rhizoctonia*, or when the bacteria alone were added to the soil, definite reduction occurred in the amount of seed decay and damping-off of cucumbers and peas. It remains for further experimentation to show whether these germs may be used in a practical way.

In nature there exist bacteriophages, substances that can quickly destroy particular kinds of bacteria. The Ohio station found in water extract from living seeds of rye, oats, winter wheat, foxtail, redtop, and timothy very strong transmissible bacteriophages capable of destroying the bacteria of tomato canker. These lysins were believed identical with that previously found in fire blight canker.

FUNGICIDES

Continued studies have been carried on at many stations which aim not only at more effective utilization of old spraying and dusting materials but also at the development of new materials and combina-

tions that may be used more successfully, easily, economically, and safely. So effective are many of the old-time dusts, sprays, dips, and fumigants in spite of certain drawbacks, that it is difficult to find suitable substitutes free from objectionable characteristics or excessive cost. Growers and farm advisers everywhere, however, have kept demanding better and safer materials, and the experiment stations, often with the aid of Department bureaus, have kept working in this direction. Encouraging results are now coming with increasing rapidity and greater efficiency in disease and insect control may be expected. Some of these advances have been noted in foregoing sections, others are mentioned here.

It is well known that many chemicals are more active the finer the size of their particles. It is not so well known that color changes may accompany changes in fineness, but the New York State station, in studying new fungicides to protect vegetables and vegetable seeds, found that cuprous oxide, commonly used in the red form, changes from red through orange to yellow as the particle size becomes smaller and that the yellower it is the more potent it is to prevent infection by fungi like those that cause damping-off, rose black spot, or potato early blight. The discovery at this station of several new types of material active against fungi was also announced, as well as the invention of a device showing how much friction in the seeder is caused by seeds treated with various dust fungicides. This device disclosed the superiority of flake graphite in reducing this friction so as to insure proper dropping of treated seed.

In studying the so-called insoluble coppers, the Delaware station found that when used with lead arsenate, although less copper injury was produced than with bordeaux adherence was not so good, arsenical injury was generally worse, and control of apple bitter rot and codling moth was inferior. Furthermore, none could safely be used with fixed nicotine and oil. Continuing studies of the effect of bordeaux mixture on plants, the Ohio station found in work with tomato, potato, tobacco, bean, cucumber, and other plants, that although it often increases the loss of water from plants, a coating of this spray also has the ability to reflect the sun's rays so that in intense sunshine the bordeaux-coated leaves are actually cooler than others left unsprayed. At such times the loss of water and danger of wilting are reduced by the spray.

Although losses from common rots of citrus have been greatly reduced in recent years through preshipment chemical treatments worked out by research, improvements are being sought. In testing the killing power of 11 different chemicals on the microscopic spores of 2 common kinds of blue mold rot at the California station it was found that the results were influenced more by the temperatures used than by the strength or duration of treatment. At 60° F., although the spores were all killed in 2 minutes by 0.4 percent sodium hypochlorite, a large proportion survived 0.4 percent chloramine-T or 6 percent sodium carbonate even when used for 5 minutes. When the temperature was raised to 110°, however, the latter materials were found to destroy most of the spores.

Among other methods of dealing with pests, the peace-time usefulness of tear gas (chloropicrin) was demonstrated by both the Rhode Island and Texas stations. It destroyed the activity of nematodes, insects, fungi, and weed seeds when injected into the soil but

had to be used at a time when no crops were growing. A simple and inexpensive method of testing the killing power of various vapors on fungi or bacteria was devised at the Wisconsin station. Field tests conducted by the Ohio station on the efficiency of the new type of spray application, in which steam vapor rather than water carries the protective chemical, indicated that while bordeaux mixture and some organic insecticides were unfavorably affected by the heat, the effectiveness of sulfur and sulfur-lime combinations appeared to be increased so as to require only about one-third the usual amount.

INSECTICIDES

That pyrethrum and rotenone insecticides can be made at less cost, and at the same time more toxic and more active, by the addition of ethylene glycol ether of pinene derived from the domestic product turpentine is a discovery growing out of researches on terpene ethers conducted by the Delaware station. The synthetic chemical, N, N, amyl benzyl cyclohexylamine with a proper emulsifier proved highly toxic to the common red spider mite and also to the troublesome onion thrips at the Illinois station. A promising insecticide among the aliphatic thiocyanates has been tested out by the Florida station to determine its toxicity to several different kinds of plants which must be known before it can safely be used. That there is no certainty that farm or waste land in certain parts of the United States can profitably be used to produce rotenone, an important imported fungicide, is indicated by an investigation of the native rotenone-containing plant, devil's shoestring, conducted by the Department (B.P.I.) and the Texas station. Although plants containing toxic constituents were found in two limited areas of the South, those from all other areas were lacking in insecticidal value. An additional use for the well-known insecticide pyrethrum was discovered at the New Jersey station where in preliminary tests it killed ticks on dogs without injury or discomfort to the animal.

Older standard materials and methods are still under investigation looking to more effective and safer use. Work conducted by the Iowa station with grasshopper baits proved that when properly used these are not injurious to wildlife. The New Jersey station added greater knowledge of how lime-sulfur and lead arsenate react on each other when combined for economy of labor and expense in orchard spraying. The amount of injurious soluble arsenic in the combination was not increased when the spray was diluted 1 to 50 with water. At dilutions of 1 to 100 or more, however, large amounts of injurious soluble arsenic were formed. This could be prevented with hydrated lime. The Alabama station, comparing the toxicity of acid lead, calcium, and magnesium arsenates to 9 species of insects that seriously infest cotton, potatoes, cucumbers, beans, tomato, corn, walnuts, etc., found that the activity of these materials depended on the acidity of the midgut of the insects concerned. The California station reported several years' work on the properties of various types of sprays which affect the deposit left on plants. With oil sprays best results occurred only where the emulsifying, wetting, and spreading properties were properly balanced and hydrogen-ion concentration of the water used was right. Wetting of waxy surfaces was possible only when the electrostatic charge was low due to wetting agents or even very low concen-

trations of certain salts. A simple, effective way of measuring the effects of dormant sprays on tree growth was worked out at the Wisconsin station. A portable instrument was invented at the Florida station to analyze hydrocyanic acid content in fumigation work. The effectiveness of fog particles of atomized or air-float oil sprays was worked out at the New Jersey station. Hot water, steam, and electrical heating devices along with a number of chemicals were tried out in the soil by the Alabama station on the larvae of the white fringed beetle. A water solution of potassium cyanide which alone appeared to offer promise was also injurious to growing plants. The electric light trap, useful against certain harmful insects, also helped the Maine station for 4 years to learn the number of generations per season and time of adult activity for more than 100 species of moths.

ANIMAL PRODUCTION, PRODUCTS, DISEASES, AND DISORDERS

CONTENTS

	Page		Page
Nutrition, management, and products.....	130	Genetics.....	154
General.....	130	Physiology.....	160
Beef cattle.....	138	Animal diseases and disorders.....	163
Dairy cattle and dairying.....	139	Horses.....	163
Swine.....	147	Sheep.....	164
Sheep.....	148	Cattle.....	165
Poultry.....	150	Poultry.....	168
Bees.....	154	General.....	171

The dominant position of livestock production in our agricultural industry is well illustrated in the latest available statistics, which placed the value of livestock production in a single year at approximately 5½ billion dollars. Milk and its products alone were valued at slightly over 2 billion dollars for the year, and cattle, swine, and poultry each were rated as approximately 1-billion-dollar industries.

A diversified and well-rounded research program is necessary to serve this great enterprise in all of its ramifications.

Broadly, the needs of the industry may be divided into the following categories: The breeding of animals inherently capable of efficiently transforming food energy into the type of end product best suited to the needs of the consumer, whether the product be work, meat, milk, eggs, or wool; a balanced nutrition to insure that every requirement of the animal will be adequately supplied at all stages of development and at the same time permit the utilization of the available feed supplies in the most effective manner; safeguarding the health of animals against infections, toxins, and parasites which might impair or destroy their usefulness; and, finally, the processing of the products in a manner that will render them most appealing to the ultimate consumer.

A fuller knowledge of the innumerable genetic and physiologic processes underlying these broad problems is essential to their final solution. Thus, the basis is laid for the extensive animal industry research program of the State experiment stations which continues to shed light on these perplexing questions.

NUTRITION, MANAGEMENT, AND PRODUCTS

In no branch of agriculture is the need for sound fundamental research and interpretation of research results into a readily available form, more evident than in the fields of animal nutrition and the processing of animal products. Examples of the manner in which the experiment stations of the several States are meeting this need are indicated in the following pages.

GENERAL

The utilization of roughages.—Range, pasture, hay, and silage crops, always important sources of nutrients in animal production in the United States, have assumed increased significance in recent years owing to the current trends in land utilization. The marked increase in production of all classes of roughage has intensified studies on means of utilizing them in maximum amounts for the various classes of livestock.

One line of attack on this problem has been extensive analyses of numerous types of herbage utilized both for grazing and cured roughage. The California station in cooperation with the Department (F.S.) in a comprehensive study of the composition of the chief grass and grasslike species, herbs, shrubs, and arborescents occurring on foothill ranges, has contributed valuable information on the influence of habitat and season on composition of range flora, which is of aid in evaluating ranges and in range management.

Similarly, studies by the Arizona and Washington stations dealing with the seasonal changes in composition of important range grasses have emphasized the decline in protein, carotene, calcium, and phosphorus contents as plants approach maturity and become dry.

The New Mexico station in comparing the monthly variation in carotene content of the important range grasses, mesa dropseed and black grama, found the former to become entirely devoid of carotene soon after the end of the growing season while the latter maintained some green stem and consequently supplied enough carotene throughout the winter to meet the vitamin A requirements of range cattle.

Analytical studies by the Texas station have revealed a rather widespread deficiency of phosphorus in forage crops for range cattle of that State. The mineral content of winter plants collected from the desert range by the Idaho station indicated a fair supply of calcium but insufficient amounts of phosphorus to satisfy the requirements of cattle. Browse plants proved superior to the grasses as a source of minerals in winter grazing. The Wyoming station on the other hand found that the common grasses, sedges, and rushes of that State were generally adequate in phosphorus and that a very satisfactory calcium-phosphorus ratio existed in the fresh plants and in hay made from them.

The Tennessee station, in studying the mineral and nitrogen content of various hay crops of the State, found that such common crops as alfalfa, *Lespedeza sericea*, and soybeans were frequently too low in phosphorus to supply adequate amounts of this element for livestock. The phosphorus content of hays from well-fertilized areas was increased as much as 40 percent over those from unfertilized areas of the same soil type. A study of seasonal trends in the composition

of improved pastures by the Louisiana station indicated that the protein, fat, calcium, and phosphorus content of the grass steadily declined with advance of the season.

The above-mentioned studies have each contributed information of value in appraising the worth of forage crops and in providing a sound basis for supplementing them in a livestock-feeding program.

Another approach to the problem is a direct comparison of various species of forage plants for a specific purpose. The Illinois station, by an ingenious technique for comparing the relative efficiency of grazing crops, has shown that young Kentucky bluegrass ranks high as a source of energy for mediumweight steers, followed in order by red-clover in early bloom, more mature red clover, young reed canary grass, late fall bromegrass, and late-bloom alfalfa.

In comparing the relative palatability of several species of grasses for steers, the Hawaii station found a spread of over 100 percent between Hilo grass, the poorest, and *Digitaria milanjiana*, the grass with highest acceptance, while Bermuda grass and natal redtop proved only slightly less acceptable than the best. Other trials at this station showed Rhodes grass to compare very favorably with Sudan grass as a roughage for milking cows while panicum grass was definitely inferior in value for this purpose. Native grasses and legumes were found by the Puerto Rico Federal station to vary widely in digestibility, biological value of their proteins, and total nutritive value.

Vitamin assays of roughages are also of significance in appraising their true worth. The Washington station showed the hay, stems, and leaves of 10-inch alfalfa to have relative vitamin G values of 50, 30, and 110 respectively, while those of 24-inch alfalfa had values of 40, 20, and 100, respectively, when compared with dried skim milk having a standard value of 100. In a sample of good green-colored alfalfa hay analyzed by the South Dakota station, the whole hay, stems, and leaves contained 2,740, 780, and 4,740 International Units of vitamin D per pound, respectively. Inferior samples of alfalfa hay contained 500 and 1,588 International Units and prairie hay 250 International Units per pound.

In comparing artificially dried, ensiled, and sun-cured alfalfa, red clover, and timothy, the Vermont station found that after 6 months' storage roughages preserved by these methods had lost about one-fourth, one-half, and three-fourths, respectively, of the carotene content of the green crops. The Idaho station found that alfalfa hay stored in the dark at 5° C. for 10 months lost 60 to 70 percent of its carotene content, whereas grass hays stored under like conditions lost little or no carotene, suggesting that a carotene-destroying factor, active at this low temperature, was present in alfalfa but not in the grasses. The California station showed that the loss of carotene in stored feeds was closely related to temperature. Practically no loss occurred in storage near 0°, while the rate of loss approximately doubled for each 10° rise in temperature.

Production and use of silage.—Experiments comparing the value of silage prepared from different crops and by various processes continue to occupy a prominent place in the station research programs.

A comparison of alfalfa silages prepared with additions of mineral acids (A. I. V. process) or molasses, at the Wisconsin station, indicated that, while the proteins and carotene were somewhat better

preserved by the former method, there was no pronounced difference in the composition of the different lots of silages nor in the amount of milk produced when each was fed to dairy cows. The latter method is considered more suitable for general farm use.

The Massachusetts station concludes that any of the annual or perennial grasses or legumes or the small grains may be successfully ensiled with additions of molasses when they are cut at the proper stage of maturity and have a moisture content of 60 to 75 percent. Molasses-grass silage was equal to corn silage and superior to phosphoric acid grass silage or cured hay for milk production. The milk produced on the grass-silage rations was higher in vitamin A content and better in flavor than that produced on the dry-hay ration.

Feeding tests with growing dairy cattle at the New Jersey station indicated that grass silage prepared with 300 pounds of molasses per ton of green material was superior in nutritive value to grass silages made with either 100 pounds of molasses or 20 pounds of phosphoric acid per ton. This suggests that the addition of substantial quantities of molasses to silage may prove an economical substitute for more expensive items in dairy rations. Both clover and alfalfa were successfully ensiled either with or without additions of molasses at the Ohio station. It was also shown here, that grass with 2 percent of molasses made good silage which was a valuable midsummer supplement to pasture for dairy cows. The North Dakota station produced excellent quality sweetclover silages by adding 70 pounds of beet molasses per ton of green clover. It was readily consumed by sheep.

Pea vines were successfully ensiled by the Washington station. However, such silage proved to be lower in digestible crude protein and total digestible nutrients (dry-matter basis) than the sun-cured vines. This station also investigated methods of utilizing cull apples as silage. Whole or pulped apples alone gave a watery, high-acid silage which was palatable to cows but imparted off-flavors to milk. A mixture of 60 percent of apples and 40 percent of freshly cut alfalfa gave a palatable, moderately acid silage with practically no loss from drainage juice and an 80-20 apple-alfalfa mixture was only slightly less desirable. Such apple-alfalfa silage compared favorably with sunflower silage as a roughage for milking cows.

The Illinois station has developed a procedure using dried whey as a preservative for grass and legume silages. The final acidity of the silage was directly related to the amount of dried whey added. The Alaska station successfully ensiled a mixture of oats and peas in a trench silo, without the addition of a preservative. The silage was in no way injured by frost. Two-foot coverings of moss, peat, or straw were equally effective in protecting the surface silage.

The Tennessee station found legume silages to be a valuable supplement to the winter ration of laying hens. Hens were able to utilize legume silage as a prominent part of the diet, and egg production was considerably higher on such a diet than on a standard poultry ration containing ground alfalfa.

The composition and nutritive value of unusual feeds.—The California station has extended its studies on the value of various byproducts to include asparagus butts, grape pomace, and cull prunes, all of

which were available in large quantities. All were found to have definite value for livestock so that it becomes an economic problem of whether they can be processed and sold for what they are worth.

The Florida station has demonstrated that dried citrus pulp is fully equal to dried beet pulp for milking cows, and as a result of the station studies, approximately 90 percent of the grapefruit-cannery refuse of the State is now being used for this purpose. Likewise, the Texas station found that dried citrus peel and pulp was about equal to ground ear corn in energy value and could successfully replace from 25 to 60 percent of the latter in the ration of fattening steers.

Assays of dried tomato pomace by the Massachusetts station showed this material to be a potent source of vitamin B₁, and a fair source of vitamins A and B₂ for animals.

The Wisconsin station, in summarizing the results of an extended series of studies, showed that oat millfeed has a reasonably high feed value for practically all classes of livestock and could successfully replace a part of either the concentrate or roughage ration for cattle, horses, and sheep, and had values ranging from 25 to 50 percent of that of corn in swine rations.

The Minnesota station investigated the composition of certain fresh-water plants which abound in the lakes and streams of that State. These generally contained more starch, though less sugar, and less crude fiber than the common cultivated hay. Certain of them, notably a species of *Elodea*, showed relatively high digestibility and biological value of protein, suggesting their value as a source of feed for livestock.

Trials at the North Dakota station indicated that leafy spurge, a serious weed pest in that State, was grazed readily by sheep after they had acquired a taste for it. This plant was found to contain about as much protein as soybean silage, though less total digestible nutrients. Such a grazing plan provided a good source of nutrients for sheep and offered a promising method of controlling the weed.

Minerals in nutrition.—Additional information on the role of minerals in animal nutrition has been gained through the continued efforts of numerous research workers, and as a result the quantitative requirements of certain classes of livestock for some of the more common elements such as calcium and phosphorus has been rather definitely established.

An important development in this field is the established significance of blood values in indicating nutritive deficiencies of various minerals. This method is particularly valuable in indicating phosphorus deficiencies before external symptoms become apparent. Application of this method is exemplified in studies at the New Mexico, Texas, and Mississippi stations. It has proved useful in locating areas in these States which yield feed crops marginal or deficient in this element, and in showing the seasonal variability in the adequacy of phosphorus supplies in pastures and ranges.

In further investigating the effects of inadequate magnesium intake in cattle, the Michigan station has described certain pathological alterations in the vascular system, particularly marked by excessive calcium deposits. Inflammation of the liver and kidneys was also noted. These findings suggest a possible relationship between low magnesium intake and arteriosclerosis of human beings.

The deleterious effect of fluorine on livestock is now generally recognized. The Wisconsin station showed that raw rock phosphate containing 0.0217 percent of fluorine could not safely be fed at a 0.4-percent level or above in the ration of brood sows. Green feed tended to raise the tolerance of swine for this element. It appeared that swine have a higher tolerance for fluorine than cattle. This station also showed that bonemeal from various sources differed markedly in fluorine content, that from the bones of veal calves containing only about 20 parts per million while that from the bones of mature cattle ranged around 500 parts per million.

The Iowa station has reported on the toxicity of various levels and sources of fluorine in the diet of rats. As little as 0.01 percent caused mottling of the teeth while at 0.1- to 0.15-percent levels reproductive failure and other complications resulted and at higher levels death generally occurred in a few weeks. The results failed to indicate a safe level at which earthy phosphates might be fed to farm animals.

The South Dakota station, in further investigating the toxicity of selenium when fed in combination with other elements, found that the addition of 5 parts per million of arsenic to the drinking water of rats completely protected against the characteristic symptoms of selenium poisoning when their diet contained 15 parts per million of selenium from toxic wheat. However, feeding arsenic to livestock as a protection against selenium poisoning is not recommended on the basis of these preliminary findings.

Sulfur in the ration of chicks caused little destruction of vitamin A but very markedly increased the chicks' requirement for vitamin D when the factor was supplied by fish oil, according to findings at the Texas station. Definite histological changes in the intestinal tract of chicks resulted from sulfur in the diet.

The Colorado station found that rations composed largely of selected feedstuffs of local origin were abnormally low in iodine, resulting in thyroid derangement or goiter in chickens. This condition was accompanied by reduction in egg weight, body weight, and viability of adult birds. Adding 5 mg. of iodine per kilogram of the deficient diet prevented the development of goiter.

The highly significant finding that manganese is an essential element in poultry nutrition has stimulated a great amount of research in this field. The Texas, New York (Cornell), Kentucky, and Michigan stations agree in their findings that 30 to 50 parts per million of manganese in the ration will ordinarily afford protection against perosis (slipped tendon disease) in chicks. The New York (Cornell) station showed certain breed differences in manganese requirement, New Hampshire Red chicks requiring more than White Leghorns to prevent perosis. They further found that the manganese content of hens' eggs increased as the content of this element in the ration increased. Good hatchability of eggs resulted when about 50 or more parts per million of manganese was supplied in the diet.

The Texas and Kentucky stations showed that certain other elements, as aluminum, zinc, and iron, exerted little if any protective action against perosis, and under certain conditions aggravated this disorder. It has also been recognized that high levels of calcium and phosphorus and possibly of other minerals in the diet increase

the incidence of perosis and require increased amounts of manganese to protect against it. A probable explanation of this phenomenon is advanced by the Colorado station which found that the precipitation of calcium phosphate or ferric chloride in the presence of manganese ions carries the latter down in the precipitate.

The Arkansas station demonstrated that pullets fed low-manganese rations produced eggs with distinctly different and inferior shell characteristics to those fed adequate amounts of this element. Rations containing 27 parts per million of manganese were inadequate for best-quality eggshells while 57 parts per million in the diet proved entirely adequate.

The Wisconsin station found that chicks suffering from perosis had lower levels of phosphorus in their blood and bones and also a lower degree of activity of the enzyme phosphatase in the blood and bones than normal chicks. It further showed that manganese had a specific activating influence on phosphatase which is probably related to the protective action of manganese against perosis.

The vitamin requirements of livestock.—Studies on both the qualitative and quantitative vitamin requirements for various types of farm animals continues to be a productive field of research.

The California station has extended to the horse its studies on the carotene requirements of animals. As with the cow, sheep, and pig, the horse requires from 25 to 30 micrograms of carotene daily per kilogram of body weight to supply its vitamin A needs. Also, the rat was found to require 15 to 20 micrograms of carotene daily per kilogram of body weight or only slightly less than is required by domestic animals. The Texas station in cooperation with the Department (B.A.I.) showed that fattening steers, when confined to a low level of carotene intake developed night blindness and finally complete blindness and made relatively inefficient gains as compared with steers receiving a more liberal amount of carotene. The optimum level of carotene intake has not as yet been determined.

The California station has confirmed its previous findings that thiamin (B_1), riboflavin, nicotinic acid (the human pellagra-preventive factor), and one or both dietary factors present in rice-bran filtrate are all essential for the proper nutrition of the pig. Further evidence on the need for nicotinic acid in swine nutrition has been reported by the Pennsylvania station. The Texas station has found that nicotinic acid is either not a dietary essential for lambs or that their requirements are much lower than that of pigs or dogs. There was little difference in the nicotinic acid content of the blood of sheep on high and low levels of nicotinic acid intake.

The Minnesota station reports that sunshine alone is not an adequate source of the antirachitic vitamin in that latitude. It appeared that white pigs stored more of this factor in their bodies during exposure to summer sunshine than colored ones. The addition of fortified cod-liver oil to the ration of fattening pigs increased both the rate and efficiency of gains, in trials at the New Jersey station, indicating the value of an adequate supply of vitamin D in swine rations.

In trials at the Iowa station goats maintained for long periods on rations in which vitamin E was destroyed continued to reproduce normally, indicating that the goat does not require this dietary

factor. Milk, butterfat, and muscle or adipose tissue from such goats, when fed to rats, resulted in resorption gestations typical of vitamin E deficiency, indicating that the goat's body becomes depleted of this factor when it is withheld from the diet.

Working with laboratory animals, the Missouri station found that a diet which supported normal growth was grossly inadequate during gestation and lactation. This dietary deficiency was corrected by a factor contained in the juice of young, vigorously growing forage plants. Methods have been devised for greatly concentrating this factor, although it is, as yet, unidentified. Also, working with laboratory animals, the Arkansas station has shown that four to six times as much vitamin B₁ and riboflavin and about five times as much vitamin B₆ is required for lactation as for growth. However, continued excessive feeding of vitamin B₁ was injurious to fertility and lactation. Choline was found to be an essential component of this complex for lactating females.

Vitamin requirements and sources for poultry.—Extensive studies in this field have added to existing knowledge regarding the nutritive requirements of fowls and have defined within narrower limits the amount of the various vitamins required for specific functions. A summary of studies at the New Hampshire station indicates that chicks have a relatively high requirement for vitamin A for rapid growth and normal body storage ranging from about 135 International Units per 100 gm. of diet during early life to approximately 400 International Units per 100 gm. of diet after 5 weeks of age. Even when fed adequate levels of vitamin A for several weeks the stored vitamin A was not sufficient to meet their requirements for more than 2 weeks during vitamin A-deficient feeding. The Wisconsin station has described a vitamin A-deficiency symptom in chicks consisting in loss of equilibrium and a staggering gait which may occur simultaneously with leg paralysis resulting from vitamin B₆ deficiency.

Findings of the California station fixed the minimum practical level of vitamin A feeding for laying hens at about 2,500 International Units per pound of ration. The Idaho station showed that a daily intake of about 0.2 mg. of carotene per hen supplied in alfalfa hay was about the minimum amount that would support fair egg production and good hatchability and prevent deficiency symptoms in the hens. Increasing the intake to 0.5 mg. daily slightly improved egg production and increased the vitamin A content of the eggs, but otherwise was of little benefit. The Wisconsin station found the vitamin A content of egg yolks to vary directly with the level of vitamin A in the ration, and further, that the vitamin A content of chicks, as well as their period of survival on an A-deficient diet varied with the amount of vitamin A in the yolk.

The amount of vitamin A required by growing turkey poults was placed by the Colorado station at about 600 units per 100 gm. of ration.

Further studies at the Ohio station indicated a requirement of about 190 to 200 micrograms of riboflavin per 100 gm. of ration to permit maximum growth of chicks from 1 to 12 weeks of age, and from 220 to 230 micrograms per 100 gm. of laying ration to give good hatchability of eggs. It appeared that somewhat less riboflavin was required for good egg production than for maximum hatchability.

The essentiality of an adequate amount of riboflavin for optimum egg production and hatchability was confirmed by the California station. This station also described a specific defect in chick embryos due to riboflavin deficiency which may serve to identify cases of deficiency of this factor in the rations of breeding flocks.

Characteristic forms of leg paralysis in chicks due to a specific neuropathology of the main peripheral nerve trunks was found by the Wisconsin station to be due to riboflavin deficiency in the diet. Supplying 300 to 400 micrograms of this factor per 100 gm. of ration prevented this disorder.

Young turkeys vary somewhat from chicks in their ability to utilize vitamin D from different sources, according to the California station. In general, however, about 200 chick units of vitamin D per 100 gm. of diet was required for normal development of turkeys to 4 weeks of age.

The Massachusetts station demonstrated that gizzard erosions readily develop in chicks maintained on a deficient basal diet. The addition of either wheat bran, wheat middlings, oat groats, or alfalfa-leaf meal to the deficient diet, gave good protection against this disorder. Very little of the protective factor was stored by the chick. Turkey poults were either unsusceptible to this disorder or very much more resistant to it than chicks. The California station found cholic acid to be an effective dietary supplement in the prevention or cure of erosions of the chick-gizzard lining and secured evidence indicating that conditions which interfere with normal bile production are conducive to the production of this disorder.

The essentiality of a dietary factor preventing a specific type of dermatitis in chicks has been previously recognized. Recently the California and Wisconsin stations simultaneously announced their respective findings on the apparent identity of the chick antidermatitis factor and pantothenic acid, thus adding to the growing list of vitamins to be isolated in pure form. Evidence obtained by the New York (Cornell) station indicated that lack of the antidermatitis factor did not affect egg production or mortality, but that its presence was required for hatchability or reproduction.

A comprehensive report by the Connecticut (State) station appears to establish nutritional encephalomalacia of chicks as a definite entity in the group of deficiency diseases. Complete protection against this disorder was obtained by administering a vitamin E concentrate or α -tocopherol, indicating that only this one factor is concerned in this disease.

Certain other new essential dietary factors for fowls have come to light during the past year. The New York (Cornell) station has reported that an unidentified factor present in yeast, milk, and cereals is required for growth and reproduction in the domestic fowl. The California station has indicated the need for a new antiparalytic factor in chick rations. Active forms of this factor have been obtained from soybean oil and from alfalfa meal. The Iowa station has described a nutritional disease of chicks caused by feeding dried eggs that is apparently due to a deficiency and not a toxicity. Findings of this nature, through the experimental use of simplified diets, continue to shed light on the adequacy of ordinary types of rations for supplying all necessary dietary factors.

Vitamin K, the antihemorrhagic vitamin, is of recognized importance not only in poultry nutrition but in human nutrition as well. The California station has made an important contribution regarding the chemical nature of this factor and particularly has developed an assay technique for determining its potency in diets.

BEEF CATTLE

Ranges and pasture for beef cattle.—A summary of the results of an extended study by the Arizona station on the value of a grassland-type range for beef cattle indicated that an area of approximately 380 acres was adequate in nutritive qualities for the yearlong maintenance of a cattle-breeding unit of 20 cows and their calves. Calcium and phosphorus supplements were in no way beneficial to the cattle on this area. Feeding cottonseed cake as a winter supplement had little effect on either birth or weaning weight of the calves and was considered impractical except in emergencies. Neither was the creep feeding of the range calves considered a feasible practice.

A 3-year study by the Alabama station of the value of rough untillable land for beef production showed that 55 acres of such grazing land would carry 19 cows for about 5 months of the year with total annual gains in weight of over 5,300 pounds. It was estimated that this pasture gave annual returns above winter feed costs, taxes, and interest of \$2.58 per acre at prevailing prices for feed and beef.

The Georgia station demonstrated that an improved permanent pasture that had been limed, fertilized, and seeded to winter clovers had 160 percent greater carrying capacity and produced 22.7 percent greater gains in steers than an unimproved pasture. Best gains were obtained in May, with good gains in April, June, and September, and but relatively poor gains in July and August.

Roughages for beef cattle.—A trial at the Michigan station gave evidence that alfalfa-clover silage, with 60 pounds of molasses per ton, was a more desirable feed for fattening steers than hay made from a similar crop. Studies on reducing the corn and increasing the hay content of rations for fattening yearling steers, by the Ohio station, gave evidence that steers receiving three-fourths full feed of corn consumed more hay, made only 0.13 pound less daily gain per head, and commanded only slight lower market price than steers receiving a full feed of corn. The ratio of acres of corn to acres of hay required for finishing the steers was 2.3:1 for the former and 5.5:1 for the latter group. Steers receiving only one-half full feed of corn consumed feed at a corn-hay acreage ratio of 1.2:1, but the average gains and market value of the steers were relatively so low that the plan is not recommended unless hay is very low in price.

A comparison of various types of silage for beef calves at the Arkansas station showed hegari silage to be practically equal to corn silage on the basis of total gains per acre of silage. Atlas sorgo silage was superior to Sudan grass silage on the basis of gains per acre but not on the basis of gains per pound of dry matter supplied. Shallu cane silage was decidedly inferior to other types in all comparisons.

A comparison of long versus ground peanut hay for fattening beef steers at the Alabama station indicated that the ground hay was more

efficiently utilized. Crediting all profit over total feed cost to the hay, the long and ground hays were worth \$17.07 and \$20.60 per ton, respectively.

Barley versus corn for beef cattle.—Findings at the Missouri and North Dakota stations agree in indicating that ground barley can successfully replace a part or all of the corn in cattle-fattening rations with only slight differences in the amount of the respective grains required per unit of live-weight gain and in the degree and quality of finish produced.

Protein supplements for beef cattle.—The Indiana station found cottonseed meal to be definitely superior to whole soybeans (either raw or roasted) as a supplement to a corn-legume hay-silage ration for fattening cattle. A complex protein mixture had only a slight advantage over cottonseed meal alone. It was further shown that meat-meal tankage compared favorably with either cottonseed meal or soybean meal both with regard to economy of gains and degree of finish produced.

A trial at the Tennessee station comparing various high-protein feeds as supplements to corn silage for 2-year-old steers found little difference in the rate and economy of gain when cottonseed meal, peanut meal, soybean meal, or a mixture of cottonseed meal and tankage were fed, indicating that price per ton should be the deciding factor in choosing between them.

Finishing beef calves.—The Oklahoma station obtained evidence indicating that creep feeding spring calves, which were fed for 160 days or more after weaning, was not an economical practice. Creep-fed calves were most profitable when marketed after a short finishing period of 60 days or less following weaning. The Michigan station found very little difference in the actual feed cost per 100 pounds of beef for calves which were creep-fed grain during the suckling period and then full-fed and marketed at about 330 days of age, and calves which received no grain while on pasture with their dams and which were fed mainly corn silage and hay until near the end of the feeding period and were marketed at about 460 days of age. Thus, the comparative price of concentrates and roughages and the average market price in spring and fall should largely determine the feeding practice to be followed.

A comparison of spring versus fall calves at the Mississippi station showed certain advantages for each lot that seemed to warrant consideration of the production of fall-born as well as spring-born calves. A higher percentage calf crop was obtained in the spring, and these calves finished at about 42 days younger age with slightly less feed required over the entire growth and finishing period. Fall calves were suckled longer, commanded a better price as feeders at weaning age, required approximately a 30-day shorter finishing period, and reached market size at the time of higher average market price.

DAIRY CATTLE AND DAIRYING

Roughage for dairy cattle.—In trials at the Virginia station comparing timothy and alfalfa hays for dairy cows, it was found that, with the same grain supplement, a timothy-hay ration resulted in about 87.5 percent as much milk as was produced on alfalfa hay.

Adding mineral supplements and yeast to the timothy-hay ration improved its efficiency. In general, milk production on the supplemented timothy and alfalfa rations was in direct proportion to the total digestible-nutrient intake supplied by the respective rations. When a roughage ration of high-grade early-cut timothy hay and corn silage was fed to milking cows at the Pennsylvania station, no benefits were derived from adding a bonemeal supplement to the ration, indicating that such good-quality roughage supplies adequate amounts of calcium and phosphorus for lactating cows.

The New Mexico station found that dairy cows fed a ration of ground hegari fodder supplemented with cottonseed meal maintained a satisfactory level of milk production, and showed no unusual physiological symptoms during a complete lactation period. However, marked symptoms of vitamin A deficiency occurred by the time these animals freshened again, characterized by calves dead at birth, blind calves, and calves with muscular incoordination, and also by night blindness in many of the cows. Apparently, the hegari fodder did not supply sufficient vitamin A and possibly other essential nutritive factors to supplement the deficiency of cottonseed meal.

Cows fed a ration consisting solely of alfalfa hay declined in milk yield at nearly twice the normal rate and produced only 45 to 70 percent as much milk as when fed normal rations, as shown by the Oregon station. Feeding small amounts of linseed, cottonseed, or peanut meals as a supplement to alfalfa arrested the rapid rate of decline in milk production and then allowed it to proceed at a normal rate, suggesting that the alfalfa proteins are incomplete for supplying the requirements of lactating cows. Tests with laboratory animals indicated that the addition of the amino acid, *L*-cystine, as a supplement to alfalfa meal markedly enhanced its lactation-promoting properties.

The Iowa station compared the efficiency of milk production for groups of cows receiving (1) a high amount of roughage with no grain, (2) a moderately high roughage and limited grain, and (3) usual levels of roughage and grain feeding. The first group showed less uniformity of feed consumption and a higher incidence of "off feed." At prevailing feed prices, the usual level of grain feeding proved more profitable than the high-roughage levels.

Extensive studies by the Washington station on the nutritive value of home-grown roughage rations gave evidence that cows maintained solely on roughages (pasture in season + hay and/or silage) produced an average of 76 percent as much milk and 72.5 percent as much butterfat as during lactation periods when grain was fed at a normal rate. There was little difference in the average daily milk production of cows fed hay alone, silage alone, or a combination of the two. In all cases cows tended to lose weight during the winter on roughage and to regain it during the pasture season.

Clover-alfalfa silage successfully replaced sun-cured hays in the winter ration of dairy cows at the Ohio station. Early-cut artificially dried hay when fed in combination with corn silage, but with no grain, sustained as high milk production as when silage, a limited amount of the same quality hay, and a half allowance of grain was fed, in trials at the Vermont station, thus indicating the possibility

of lessening milk-production costs through the feeding of such high-quality hay.

At the Florida station, Napier grass grazed by a rotation system with Jersey cows supported high milk yield over a period of 107 days. Digestion trials with the freshly cut grass showed the dry matter to contain 8.5 percent of digestible crude protein and 65 percent of total digestible nutrients.

Fat in the dairy ration.—The importance of a certain level of fat intake by dairy cows for maintaining maximum yields of milk and butterfat production was further substantiated in recent trials at the New York (Cornell) station. Cows fed rations including ground soybeans and containing over 5.25 percent of fat consistently showed an advantage in milk production over cows fed rations in which soybean meal replaced the ground soybeans and containing 3.35 percent of fat or less. Ground soybeans are considered a satisfactory and practical source of the fat needed in the ration.

The Michigan station found that the addition of soybean oil to a low-fat basal dairy ration immediately resulted in an increase in milk production and a temporary sharp rise in the percentage of butterfat in the milk. However, within a short time the butterfat percentage returned to normal. Moderately increasing the fat content of the basal ration by replacing beet pulp with corn increased the level of milk production but did not affect the percentage of butterfat in the milk. Replacing a high-fat ration by one low in fat decreased milk production, but caused an increase in butterfat content. Thus it appeared that the character of the basal ration was an important factor in determining the effect of adding fat to the ration on milk and butterfat secretion.

The Iowa station found that adding cracked soybeans to a dairy ration slightly depressed milk production but markedly increased the percentage of fat in the milk with a resulting increase in total butterfat production. On the other hand, feeding soybean meal plus soybean oil tended to increase milk production while the percentage of butterfat was depressed. Furthermore, the oil feeding resulted in soft butterfat high in oleic acid, while cracked soybeans gave a firmer butterfat high in linoleic acid, indicating that the form in which fat is ingested affects the fat metabolism of the animal.

Nutrition of dairy calves.—Reports from the Wisconsin and Hawaii stations indicated that calves can utilize nonprotein nitrogen in the form of urea when it replaces a part of the protein in the ration. The Ohio station found that calves fed skim milk plus an animal fat fortified with vitamins A and D made practically as good gains as whole-milk-fed calves. When the vitamin supplements were omitted in the former diet a high percentage of calves succumbed to pneumonia. Vegetable oils such as cottonseed, soybean, or corn oils could not satisfactorily be substituted for butterfat in the ration of young calves in trials at the Minnesota station.

Growing dairy calves fed a rickets-producing diet but exposed daily to artificial ultraviolet irradiation equivalent to 2 hours of mid-summer sunshine were protected against rickets as shown by the Ohio station. Applying the ultraviolet rays to the region back of the withers was almost as effective as applying it to the head region.

Calves at the Pennsylvania station developed symptoms of vitamin A deficiency in a relatively short time when fed skim milk, poor-quality timothy hay, and a low vitamin A concentrate mixture. Fresh carrots, artificially dried alfalfa hay, or a carotene concentrate were effective in preventing and curing the avitaminosis A. The relative amount of vitamin A in the livers of calves closely corresponded to the level of carotene intake.

The Minnesota station has further described the physiological disorders arising from confining calves to a whole-milk ration. It was found that nearly all of the recognizable symptoms of the syndrome developed on the sole milk ration were remedied by supplementing milk with iron chloride, copper sulfate, magnesium carbonate, and cod-liver oil. Similarly, the Ohio station found that calves maintained on whole milk supplemented with iron and copper soon developed abnormally low blood- and bone-magnesium values. Adding magnesium carbonate to the mineralized milk diet markedly improved this condition.

The South Carolina station demonstrated that by reducing the rate of milk intake of calves through use of a feeding pail equipped with a rubber nipple, practically all of the milk passed directly into the abomasum or fourth stomach and that by this process digestive disturbances were almost completely eliminated. Open-pail feeding resulted in milk breaking through the esophageal groove and passing into the rumen where excessive fermentation occurred.

The composition of bovine blood.—Increased interest has been manifested in determining the range of values for various constituents of the blood under conditions of normal and abnormal nutrition. The Michigan station found that in normal dairy calves blood-magnesium values generally ranged between 1.9 and 2.8 mg. per 100 cc. of blood plasma. It appeared that fluctuations within this range are to be expected as normal occurrences in growing calves. This station has also perfected a method for the determination of carotene in blood and has obtained data showing the marked effect of spring pasture grass in increasing blood-carotene values in cattle. Studies at the New Mexico station revealed a close relationship between the carotene level in the blood serum and in butterfat from individual cows.

At the Pennsylvania station, studies on the inorganic phosphorus content of the blood of normal dairy cattle showed that values in immature animals decline with advancing age in a regular manner, ranging from 6.4 mg. per 100 cc. of blood in calves under 7 months of age to 4.7 mg. for calves 25 to 30 months of age. Average values for milking cows, dry cows, and all cows were 4.28, 4.35, and 4.29 mg., respectively.

Quality and flavor of milk.—Findings of the Kansas, Washington, New Jersey, and New Mexico stations agree in showing the pronounced effect of feeding grass and other rich sources of carotene to dairy cows in increasing the carotene and vitamin A content of milk, although the percentage recovery of ingested carotene in the butterfat is relatively very low. The optimum level of carotene intake necessary to insure high-quality milk appeared to be many times greater than the minimum required to prevent recognizable deficiency symptoms. The Kansas station further showed that low carotene

intake was regularly associated with milk susceptible to oxidized-flavor development, while high levels of carotene intake remedied or prevented this flavor defect. However, feeding cod-liver oil to provide an equivalent amount of vitamin A had no influence on milk flavor. Adding legume silage to the dry winter ration of milking cows more than doubled the vitamin A activity of the milk produced, as reported by the Michigan station.

The Kansas station in a systematic study of factors affecting the riboflavin content of milk found that samples collected in July after cows had been on pasture for several weeks were somewhat higher in this factor than early-spring samples, but concluded that climate and rations are not the only important factors causing these variations.

The New York (Cornell) station determined the ascorbic acid content of milk from several species of mammals and concluded that there was a pronounced direct effect of the amount of ascorbic acid ingested by animals on the amount of this factor contained in their milk. Neither the Kansas nor the West Virginia station was able to show a direct relation between the amount of ascorbic acid in milk and susceptibility of milk to oxidized-flavor development, although the latter found that adding ascorbic acid to the ration of cows reduced the tendency for metal-induced oxidized flavor to develop in the milk.

The Michigan station showed that the stability of ascorbic acid against oxidation was greater in summer than in winter milk and further that oxidized flavors occurred more frequently in both raw and irradiated milk produced in winter than in summer. However, the New York (Cornell) station found little difference between summer and winter milk in the above respects.

The Virginia station demonstrated that milk pasteurized in an atmosphere of carbon dioxide was a much more potent source of vitamin C (ascorbic acid) than milk pasteurized in the presence of air. The New York (Cornell) station found that both the destruction of ascorbic acid and oxidized-flavor development were largely or completely prevented by removing the dissolved oxygen from milk. In this connection, the station has developed a vacuum cooling process which, when applied to hot milk, draws off the water vapor and sweeps out the dissolved oxygen along with it. This process lowers the temperature of milk about 18° and can be applied as a part of the cooling necessary after pasteurization. Milk bottled and capped after vacuum cooling showed no loss of vitamin C nor oxidized-flavor development over 7 days, while surface-cooled milk developed a strong oxidized flavor with marked destruction of vitamin C within 3 days.

A report from the Michigan station on the effect of heat on milk flavor indicated that cooked flavor was produced by heating whole milk from 76° to 78° C. momentarily, 74° to 76° for 3 minutes, or 70° to 72° for 30 minutes. Skim milk required 2° to 4° higher temperature to produce this flavor defect than whole milk. The cooked flavor is attributed to the formation of sulfides that occurs when milk is subjected to sufficiently high temperatures or to other changes occurring simultaneously with sulfide formation.

Continuing studies on the effect of various alloys used in dairy-processing equipment on milk flavor, the California station found that the incorporation of small percentages of tin and zinc in copper-nickel alloys markedly inhibited the solubility of copper by milk and thus reduced the tendency to oxidized-flavor development. Both this station and the Michigan station have shown that the rate of oxidation of vitamin C in milk is a delicate test for detecting the presence of copper dissolved from the metals of dairy equipment.

Further studies by the Wisconsin station have demonstrated that the characteristics of the milk film, the intensity of ultraviolet irradiation, and the distance of the milk film from the source of irradiation are each very significant factors in determining the final vitamin D content of irradiated milk. Methods have been outlined for controlling these factors to give a maximum vitamin D potency with a minimum effect on other constituents of milk. Activated flavor due to intense ultraviolet irradiation was found to arise in the protein fraction of the milk and to be practically identical with the burnt flavor which develops in milk exposed to sunshine. Oxidation of milk samples tended to remove the activated flavor.

The nutritive value of chocolate milk.—The Massachusetts station found that the addition of 1 percent of cocoa to whole milk does not decrease the digestibility or nutritive value of milk but that 4 percent of cocoa markedly retarded the rate of digestion and decreased the final digestibility of milk proteins. It is recommended that not over 5 percent of sugar be added to chocolate milk and that the total fat content should meet the legal standards for whole milk.

Butter production.—A summary of 10 years' work by the Mississippi station on the effects of various feeds on fat constants, flavor, and texture of southern butter emphasized the effect of feeding cottonseed products, which generally resulted in a hard gummy butter. Extracting most of the oil from cottonseed meal reduced the gumminess of the butter but did not reduce firmness to any marked degree. Feeding silages or soybean meal with cottonseed meal improved the texture of butter. Cured sweetpotatoes and dried sweetpotato pulp in the ration each tended to give a firm-textured butter, with the former imparting a very pleasing flavor. It is emphasized that moderately firm butter is desirable under southern conditions.

Experiments at the Minnesota station on the use of rollerless churns indicated that with properly regulated loads this type of churn will produce uniform butter with no greater fat loss than the roller churn, but that moisture will not be as well incorporated. This station also showed that relatively high pasteurization temperatures and proper control of acidity of cream were practical means of controlling cheesiness in butter. Other studies gave evidence that the development of incipient flavor defects in butter, such as flat, bitter, stale-storage, and metallic, were due to oxidation of the lecithoprotein complex. Certain of the milk plasma ingredients, particularly the inorganic salts, possess highly antioxygenic properties that naturally tend to hold such flavor defects in check. This station also found that the soaking of parchment paper used for wrapping butter in 16- to 20-percent solutions of either sodium or calcium propionate was an effective method of inhibiting mold development in butter during storage.

A study of the significance of mold mycelia in butter by the Indiana station indicated that 20 to 30 percent of the mold present in cream is carried over into the butter. The amount present in butter serves as an index of length of holding time, storage temperature, and oxygen relationships of the cream from which the butter is made but is not a direct index of organoleptic quality of the cream.

The desirability of uniform moisture dispersion in butter was brought out by the Iowa station which showed that more rapid bacterial growth and more rapid spoilage occurred in underworked than in thoroughly worked butters.

Cheese production.—The Iowa station, in studying the fat of Cheddar cheese, found that important flavor constituents are contained in the fat. Raw-milk cheese regularly contained fat of higher acid number than pasteurized-milk cheese. The former also developed flavor more rapidly during ripening than the latter, suggesting that rate of increase of acid number may explain the difference in ripening qualities of the two lots. This station has also studied the flavor of Swiss-type cheese, and has shown that the propionates are important flavor contributors. A process for the manufacture of special Swiss-type cheese which has yielded an excellent quality product when employed on a semicommercial scale has been described.

The Minnesota station found that the addition of commercial steapsin to cheese curd markedly accelerated the rate of flavor production in Roquefort-type cheese, provided the cheese was inoculated with *Penicillium roqueforti*. Cheese receiving steapsin but no mold inoculation became rancid, and developed none of the typical blue-cheese flavor.

The New York State station has shown that efficient pasteurization is effective in properly controlling gas formation in Limburger cheese, and that high-quality cheese can be made from pasturized milk. It was further shown that proper control of hydrogen-ion concentration and salt are important in maintaining the desired bacterial flora on the surface of ripening Limburger cheese.

Continuing studies on brick cheese, the Wisconsin station showed that degree of acidity in green cheese is closely correlated with the acid grade of cured cheese, and that the minimum pH value of 3-day-old cheese should not be below 5.1. Splitting of brick cheese appeared to be due to a combination of circumstances favoring excessive gas formation rather than to any single factor. Lack of acid development, low salt content, and large-sized loaves all tended to encourage late gas production.

Physical and chemical properties of milk and milk products.—Studies at the Minnesota station gave evidence that the curd tension in normal milk is not seriously affected by butterfat hydrolysis but, in the presence of unnatural emulsifying agents, lipase activity liberates certain fat acids which markedly reduces the curd tension of the milk.

The New York (Cornell) station found that fat lipolysis occurs in practically all raw-milk samples, although milk from individual cows varied widely in this respect. Rapid cooling tended to retard the rate of lipase action while lipolysis in cold milk was sharply accelerated by warming the milk slightly and then recooling it.

Shaking fresh raw milk while the fat is in a liquid or partly liquefied state also increased the rate of lipolysis. In another study, it was shown that the physical condition of milk fat is a controlling factor in butterfat losses during centrifugal separation of milk. Milk adjusted from a low temperature upward to 85° F. for separation showed higher losses than milk adjusted downward from a high temperature to 85°.

The California station found that the physical and chemical state of fat exerted a marked effect on the foaming properties of casein solutions used in paper coating. Casein prepared from buttermilk high in fat had a low foaming index. The addition of diglycol laurate to milk used in casein manufacture prevented foaming. The California and Arizona stations agreed in showing that dry milk solids prepared by the spray process have greater water-absorption capacities than those prepared by the roller- or drum-type process. The latter station also showed that skim-milk and sweet-buttermilk powders absorbed less moisture than sour-buttermilk powder and that the dispersibility of the sweet-milk powder was considerably higher than that of the acid-buttermilk powder.

Bacteriology and sanitary control.—As a result of extensive experiments by the New York State station and others, showing the superiority of certain media over standard nutrient agar for making bacterial counts of milk, a new medium has been officially adopted by the American Public Health Association, effective July 1, 1939. The Kansas station, in comparing the old and the new media, showed that the new one gave materially higher total counts and supported numerous types of organisms of significance in dairying that would not grow on the old one.

Further studies at the Michigan station showed rather close agreement between the direct microscopic bacterial counts of milk and the methylene blue reduction and sediment tests, indicating that both are valuable tools in appraising the sanitary properties of milk. The Arizona station found that, while physiological types of bacteria varied in their ability to reduce methylene blue in milk, variations in the predominating type in individual milk samples failed to have any material effect on reduction time. Apparently, the associative action between bacteria overshadows any individual variation of reducing ability.

The Iowa station, working with organisms isolated from evaporated milk, and the Wisconsin station, working with Swiss-cheese-starter cultures, found that the growth temperature of cultures and also time of incubation exerted a marked effect on the thermal resistance of the organisms.

Slow acid production in butter cultures under certain conditions was found by the Iowa station to be due to a specific inhibitory principle which had the general characteristics of a bacteriophage. No method was found for eliminating this principle from butter cultures but strains of *Streptococcus lactis* not sensitive to the inhibitory agent could be used in forming a good butter culture.

Tests at the Kansas station indicated that different lots of resazurin dye varied greatly in their behavior in milk, indicating a need for careful standardization of the dyes before the resazurin test could be applied with uniform success to the grading of milk.

The value of the phosphatase test for determining the efficiency of pasteurization of dairy products has been further confirmed during the year. However, the Illinois and Kansas stations have encountered certain difficulties in applying this test to ice-cream mixes, with evidence that the additional solids in the mix, particularly sugar, act as a protective agency for the enzyme phosphatase. Coloring and flavoring materials also affect the accuracy of the test. The latter station found that phosphatase is more heat resistant than even the more heat-resistant strains of bacteria in the coliform group. Hence, the presence of such organisms in an ice cream or ice-cream mix that gives a negative phosphatase reaction indicates recontamination of the mix during or following pasteurization.

The Maryland station has shown that cream intended solely for manufacturing purposes can be labeled by the addition of annatto extract. The presence of this harmless color can be positively identified even though labeled cream is greatly diluted with other cream not containing the color.

SWINE

Grains for swine.—The comparative value of various grains for growing and fattening swine continues to receive considerable attention of experiment station workers. The Missouri station found that in fattening pigs weighing from 50 to 200 pounds ground barley was 85 to 90 percent as valuable as corn, pound for pound. Gains on the barley ration were considered satisfactory but were about 8 percent slower than with corn-fed pigs. The South Dakota station showed that mediumweight and lightweight barleys were only slightly inferior to heavy barley or corn for fattening pigs. There was little difference in total gain per pig on the various rations although slightly more of the lighter-weight barleys was required per 100 pounds of gain. It appeared that lightweight barley could be used for pig feeding to better advantage than attempting to sell it on the grain market.

In a trial at the Michigan station spelt and oats were found to be practically equal in feeding value when each was fed in combination with corn and a protein supplement to fattening pigs. The Iowa station compared corns of three degrees of hardness for pigs and concluded that the hardness of corn has no appreciable effect on the amount of grain consumed daily per pig or the rate of gains. Apparently, the hard type of corn was masticated and digested as well as the softer types.

The Hawaii station replaced one-fourth to one-third of the grain in swine-fattening rations with cull fruit of the papaya and avocado without materially reducing the rate of gain and at a significant reduction in cost of gain. Such feeding practices render the swine producers less dependent on outside sources for feed.

In experiments at the New York (Cornell) station comparison was made between the relative efficiency of limited and full feeding for fattening pigs in dry lot. Those fed at three-fourths of a full-fed rate required slightly less feed per unit of gain but made less economical gain than full-fed pigs because of the longer time factor involved. The pigs fed at one-half of the full-fed rate made the slowest and most expensive gains of the three lots. Hogs pastured

on green oats and peas and fed a mixed grain ration made more economical gains than pigs fed the same concentrate mixture in dry lot, in trials at the Alaska station.

Protein supplement for swine.—Further studies have been conducted on the use of cottonseed meal in swine rations. A summary of extensive investigations at the Ohio station gives further evidence that untreated cottonseed meal when used as a sole protein concentrate for pigs in dry lot has a pronounced injurious effect resulting in a high percentage of deaths. Adding vitamin A to the ration does not overcome this injurious effect. Meals manufactured by different processes varied in their toxic effect, but all meals were rendered harmless by heating them with steam for 1 hour under 14 pounds pressure or by treating them with a solution of ferrous sulfate at the rate of about 3.4 pounds of this compound per 100 pounds of meal. Cottonseed meals treated in this manner were approximately equal to linseed meal as a part of the protein concentrate for pigs.

Trials at the Mississippi station indicated that a ration of corn and cottonseed meal (70:30) could be successfully fed to pigs that had access to alfalfa pasture. Less satisfactory results were obtained in feeding this mixture to pigs on wheat or Sudan grass pasture, and under these conditions reducing the amount of cottonseed meal and adding some tankage to the mixture is recommended. A comparison of protein concentrates for pigs at the Georgia station indicated that, with young pigs, a mixture of cottonseed meal and tankage was superior to tankage alone which in turn was superior to a tankage-peanut meal mixture. With heavier pigs the latter mixture was more efficiently utilized, suggesting that young pigs do not thrive on the peanut-meal proteins.

At the Michigan station, ground alfalfa mixed with corn in the ratio of 1:2 proved just as effective a ration for bred sows as a ration of corn supplemented with 6 percent of tankage. The Delaware station found rape pasture to be superior to sweetclover pasture in saving protein supplement for growing and fattening pigs. It further showed that tankage is far superior to either dried distillers' grains or dried brewers' grains as a source of protein for fattening pigs.

Trials at the Hawaii station indicated that yeast made locally from cane molasses and containing 40 or 45 percent of protein could partly or wholly replace a protein supplement of fish meal and soybean meal without reducing the rate of feed intake or rate of gain for fattening pigs.

Peanuts for pigs.—The North Carolina station has shown that firm pork can be produced from peanut-fed pigs, provided that peanut feeding is discontinued when pigs reach a weight of about 100 pounds and thereafter a hardening ration is fed, and further, that over the hardening period approximately 4 pounds of corn or its starch equivalent is fed for each pound of shelled peanuts consumed during the softening period.

SHEEP

Flock management.—The Idaho station in cooperation with the Department (F.S.) compared the returns secured from farm flocks grazed on national-forest summer range with those from flocks kept on farms throughout the year. The summer losses of ewes and lambs,

the weight of lambs produced, and the annual net returns per ewe all favored the yearlong farm flock, which largely explains the instability of permits to graze farm flocks on national-forest summer range.

The South Dakota station, in comparing the relative economy of feeding western lambs and western cull or "gummer" ewes, found that the lambs returned about 50 or 60 cents more per head, or roughly, 40 percent more above feed costs, than the ewes, indicating that unless the ewes could be purchased at a very low cost lamb feeding would likely prove more profitable. The meat from the finished gummer ewes graded surprisingly high.

The Maryland station in cooperation with the Department (B.A.I.) found no significant difference in the rate of gain of wethers and rams, either on pasture or in dry lot, to 1 year of age. The wethers averaged about 2 percent higher in dressing percentage and showed a greater weight of total fat than the rams while the latter showed a greater weight of bone, head, caul fat, and pelt. Slight differences in quality of meat favored the wether carcasses.

Rations for breeding ewes.—The North Dakota station found that chopped or ground Russian-thistle hay moistened with water and molasses and fed with a small amount of barley constituted a satisfactory ration for wintering bred ewes. The addition of molasses was essential to insure palatability. In trials at the Minnesota station, adding mineral alone was not adequate to render prairie hay a complete ration for wintering ewes. Protein equivalent to two and one-half times and phosphorus equivalent to two times that in the hay were required to properly balance the ration. At the Alaska station bred ewes wintered on chopped beach hay, an abundant and cheap source of roughage for the Matanuska area, remained in as good physical condition and produced as many lambs as ewes wintered on either long or ground oat-and-pea hay. In a trial at the Kentucky station bred ewes fed alfalfa hay gained more during the trial and came through the experiment in more vigorous condition than ewes receiving either Korean lespedeza or *Lespedeza sericea*. However, there was little difference in number or size of lambs produced by the various lots.

Rations for fattening lambs.—The Texas station found that lambs receiving alfalfa hay as a roughage in the fattening ration made decidedly larger gains than lambs receiving sorghum roughage (fodder or silage). However, the addition of calcium (pulverized oyster-shell or limestone) to the sorghum roughage at the rate of about 0.4 ounce per head daily resulted in larger gains and in carcass quality similar to that produced by the alfalfa.

A comparison of the biological value for growing lambs of proteins in rations containing alfalfa hay or timothy hay, by the New York (Cornell) station, gave evidence that a ration of corn and timothy hay when supplemented with soybean meal furnished protein of as high efficiency as a ration of corn and alfalfa. Further trials by this station showed a much higher protein storage in lambs receiving rations containing solvent extracted soybean meal (either with or without special heat treatment) than in those receiving raw soybeans or soybean flakes.

Trials at the Georgia station indicated that the nutrients supplied by sweetpotatoes were utilized fully as well by fattening lambs as those supplied by ground white corn. Gains were practically equal on the two types of rations. The Idaho station showed that cull potatoes could successfully replace a part of the alfalfa hay in the winter ration of lambs. Approximately 340 pounds of potatoes were required to replace 100 pounds of alfalfa. Lambs receiving alfalfa and potatoes yielded more wool than those on alfalfa alone.

POULTRY

Metabolism of fowls.—The New Jersey station found that the mortality, growth rate, and utilization of food energy in young chicks are markedly affected by the environmental temperature. Temperatures of 16° to 18° C. approached the lowest limits at which chicks could survive. Within a temperature range of 16° to 38° food consumption was approximately a linear negative function of temperature. Fat storage in the body was greatest at 38° while no fat storage occurred at 16°. Heat production per unit of body weight was greatest at the lowest temperature while the efficiency of food utilization was greatest at the upper temperature limit.

Experiments at the California station indicated a steady rise in metabolic rate with increasing age of young chicks, amounting to from 0.2 to 1 percent per day per unit of body weight and about 3 percent per day per unit of body surface area.

Temperatures prevailing during the growing season exert a pronounced effect on the growth rate of chicks as determined by the Missouri station. Early-hatched birds grow at a more rapid rate than later-hatched during the first 20 weeks of life. High temperatures also materially affect the blood-calcium level of hens, according to findings of the Kansas station. Increasing the environmental temperature from 70° to 90° F. decreased the blood calcium from 25 to 30 percent, which tends to explain the adverse effect of high temperature on thickness of eggshells. This station also found that marked fluctuations occur in the phosphatase and inorganic phosphorus in the blood of hens during an egg-formation cycle. The concentration of both these constituents in the blood was much higher at the time of active shell deposition than at the beginning of the cycle suggesting that phosphatase may play an important role in eggshell formation.

Relation of body conformation of live fowls to carcass grade.—The Oklahoma station has established a definite relation of certain body measurements and live weight of both chickens and turkeys to the conformation of the dressed carcass. Thus, by obtaining the weight and certain measurements as shank length, keel length, and minimum anterior depth of live birds and comparing these with standard tables, the carcass grade can be accurately predicted.

Artificial illumination for laying flocks.—The feasibility of artificial lighting for laying hens has been further demonstrated. The Maryland station showed that lighting to provide 15 hours of illumination daily from July 1 to January 1 for pullets completing their first laying year increased production about 24 eggs per pullet and returns over feed cost about 50 cents per pullet as compared with birds not receiving artificial light for this period. The Delaware station found that artificial lighting during the short daylight

season increased egg production when egg prices were relatively high, resulting in an average price increase of about 1.8 cents per dozen or approximately 50 cents greater return per bird over the laying year.

Turkeys may be brought into earlier laying and the total number of eggs produced per hen to the end of June increased by artificial lighting, according to findings of the Iowa station. It required about 6 weeks for turkeys to reach a reasonable level of egg production after lights were turned on.

Grains for poultry.—Tests at the Indiana station indicated little difference in the efficiency with which medium or coarsely ground wheat was utilized by young chicks. However, finely ground wheat was unsuitable for chicks since it became sticky and adhered to the mouth parts, resulting in crooked beaks in a high percentage of the birds.

The Nebraska station found no significant differences in rate of growth or in the percentage retention of nitrogen, calcium, or phosphorus when 31 percent of ground sorghum grain (kalo) replaced an equivalent amount of ground corn in chick-growing rations. A comparison of various single grains in poultry rations at the Iowa station revealed that egg production was higher when corn was the only grain ingredient than when oats were fed, while that on a wheat ration was still lower. However, the order of hatchability of eggs was reversed, being highest on the wheat ration followed in order by the oat and corn rations. Moreover, chicks from hens fed oats or wheat were more vigorous than those from corn-fed hens.

The production of proso millet is rapidly increasing in the northern great plains area because of its drought-resistant qualities. The South Dakota station showed that either red or white proso could successfully supply at least half of the grain portion of laying rations. Red proso in combination with either oats, barley, or wheat proved satisfactory in starting and growing rations. Similarly, the North Dakota station found that proso could successfully replace one-half or all of the yellow corn in starting and growing rations for turkeys. Millet-fed birds consistently outweighed the corn-fed at marketing time. However, slightly more of the millet rations was consumed per pound of gain.

The California station showed that the inclusion of 15 to 25 percent of red wheat bran in the growing ration of chicks resulted in more rapid growth and early sexual maturity of the pullets.

At the Kentucky station replacing a part or all of the corn with thick distillery slop in rations for chicks adversely affected the degree of fatness, the hardness of the fat, and the flavor of the finished bird. Rations containing little or no corn resulted in a decidedly inferior product. A study of the nutritive value of distillery byproducts at the Massachusetts station indicated that the protein of both dried distillers' grains and concentrated distillers' slop were relatively poor in growth-promoting qualities, but that both should provide economical and satisfactory sources of vitamin B₁ and riboflavin when used in limited amounts in poultry rations.

Studies at the Western Washington station showed that oat hulls contain a factor that largely or entirely prevents cannibalism among chicks. The exact nature of the factor has not been determined, but

it is apparently organic in nature since the addition of oat-hull ash to the ration was of no value in reducing cannibalism.

The Minnesota station found that the extraction of rye grains with hot water removed certain objectionable factors which caused unpalatability, diarrhea, and toxic effect when fed to chicks.

Proteins for poultry.—In extensive tests at the New Hampshire station to determine the optimum level and source of animal protein for chickens, it was found that fish meal alone was superior to either meat scrap or dried skim milk as the principal protein ingredient in both growing and laying rations. As protein levels increased from 15 to 19 percent the rate of growth increased. The level of protein did not affect age and sexual maturity, nor size of egg laid. The Nebraska station comparing the efficiency of feed utilization by chicks on rations containing 16 and 22 percent protein, concluded that greater gains are made on the same dry-matter intake at the higher protein level but that greater gains per unit of nitrogen consumed are made on the lower level.

The Iowa station found that the average egg production (November 1 to September 30) of hens receiving dried skim milk as a principal source of protein was higher than that of hens receiving meat-and-bone meal, or a combination of the two protein supplements. Differences between the various groups were less significant on the basis of 12 months' (October 1 to September 30) production.

Soybean meal proved much superior to corn-gluten meal as a source of protein in poultry rations when each was fed as a sole protein concentrate, or in combination with animal protein, in trials at the West Virginia station. Trials at the Ohio station indicated that toasted solvent-extracted soybean meal compared favorably with expeller process soybean meal when each was fed as a sole protein supplement, or in combination with animal protein, to growing chicks.

A comparison of rations containing various levels of dried skim milk led to the conclusion at the Pennsylvania station that for growing rations most efficient gains were made by chicks receiving 1.25 to 2.5 percent of this feed. From the standpoint of egg production, egg weight, and hatchability, 2.5 to 3.75 percent of dried milk gave essentially as good results as higher levels.

Results at the North Carolina station indicated that peanut meal could replace either fish meal, meat scrap, or dried buttermilk in the North Carolina open-formula laying mash with entirely satisfactory results.

The Texas station, comparing numerous combinations of protein supplements for growing chicks, concluded that any combination containing three ingredients selected from sardine meal, meat and bone scrap, dried skim milk, cottonseed meal, and soybean meal could be recommended to give good results except a mixture of sardine meal, meat and bone scraps, and soybean meal, which resulted in excessive mortality of chicks. In general, the presence of sardine meal in the ration regardless of other ingredients promoted more rapid gains than when this feed was omitted.

Turkey production.—Experiments reported by the Washington, Michigan, and California stations gave evidence that the protein requirements of growing turkeys decline with advancing age, and that when supplied with a well-balanced mash ration of reasonably high

protein content and ample amounts of scratch grains the birds will properly balance their rations and show satisfactory gains and finish. The Oregon station reports that 15 percent of protein in the ration gave less satisfactory finish in fattening birds than higher levels. The Utah station found that the common practice of feeding soaked ground grains and alfalfa meal or wet mash to growing turkeys tended to increase feed consumption per bird but also increased the feed required per pound of gain as compared with dry feeding. There was little difference in finished weight or condition of turkeys under the two systems.

The Wyoming station, in further investigating the problem of deformed breastbone in turkeys, has shown that the use of 4-inch pole roosts or 4-inch and 6-inch flat roosts tilted at a 20° angle results in much less breastbone indentation than when birds roost on 1-, 2-, 4-, or 6-inch flat roosts not tilted or 4- and 6-inch flat roosts tilted at a 7° angle.

The Virginia station has shown that the inclusion of menhaden fish meal in turkey rations throughout the fattening period results in a pronounced fishy flavor in the carcass. When only 10 percent of the fish meal was used, the fishy flavor was prevented by eliminating fish meal from the ration 4 weeks before killing, but with higher levels fish-meal feeding must be discontinued earlier in the fattening period. Trials at the North Dakota station indicated that turkey capons grew at a slower rate than young toms, while cooking tests failed to show any superiority of capon meat.

Egg quality.—The egg industry has long been confronted with the need of more reliable tests than those now available for measuring the quality of unbroken eggs. The Indiana station has adapted a delicate balance (Jolly balance) for determining the buoyancy weight of eggs and has found a significant difference in buoyancy weight of fresh and stale eggs which may serve as a basis of differentiation through use of this method.

The Washington station has developed an apparatus for measuring the resistance of eggshells to crushing and puncturing forces, and by use of this equipment has established the relationship between shell thickness and its resistance to crushing or puncturing. Other studies at this station have more definitely established the close relationship between storage temperature and rate of deterioration in interior egg quality. Eggs stored at 30° F. declined about 44 percent in albumin score in 192 days while at 50°, 70°, and 90° storage temperature loss of score progressed at increasingly rapid rates, amounting to about 72 percent in 8 days at 90°.

The Ohio station showed a close relationship between humidity of the storage room and ability of eggs to retain quality score in storage. At comparable storage temperatures, practically all eggs held at a relative humidity of 38 percent dropped from U. S. Extra to U. S. Standard grade in 10 days while those similarly held at a relative humidity of about 77 percent retained the high grade.

The California station found that the egg defects characterized as olive-yolk and pink-egg types were due to constituents in the ration. Cottonseed meal appeared to contain substances causing both types of defects. Gossypol produced the former type while the latter was due to a different substance present in numerous members of the plant family Malvaceae.

Distinct variations occur in the character of eggs produced by different breeds of chickens according to findings of the New York (Cornell) station. For example, eggs from Barred Plymouth Rocks were relatively low in weight and percentage of shell and of inner thin white but high in amount and percentage of thick white, while those of Rhode Island Reds were higher in percentage of inner thin white and those of White Leghorns higher in percentage of outer thin white.

Studies at the California station, on the rate of deterioration occurring during the incubation of infertile eggs, showed that a slight decrease in quality was evident after 2 hours. After 15 hours there was a drop of about 65 percent in candling score, although the drop in interior egg quality was actually much less than was indicated by the candle. Such eggs had a poaching quality very similar to that of U. S. Standard eggs.

The South Carolina station reported that the presence of green feed in the hens' ration did not affect the percentage and height of firm albumin or the yolk index of the eggs.

BEES

Nutrition studies.—The Minnesota station found that cottonseed meal or soybean flour mixed with 20 percent of dried skim milk were very effective substitutes for pollen for feeding bees in early spring. The cottonseed meal-dried milk mixture was as useful as bee bread for this purpose.

Colonies of bees abundantly supplied with pollen reared broods at a 22-percent faster rate and produced 21 percent more honey than colonies dependent on pollen from natural sources, as determined by the North Dakota station.

GENETICS

In the research of the experiment stations, an important and fundamental phase concerns the determination of the genetic factors responsible for the inheritance of characters in livestock, especially those characters of economic importance related to production and reproduction. This work has as its ultimate objective the production of families and strains of the various classes of livestock and poultry carrying desirable combinations of superior qualities which may be transmitted to their progeny with uniformity. A knowledge of the fundamentals concerned with reproduction and lactation may be expected to prove of value in natural and artificial breeding practices and to result in improvements in economical milk production.

Improvement in milk production in dairy cattle.—The Iowa station found in a study of the milk production of ancestors, progeny, and mates of 303 Holstein-Friesian bulls proved in Iowa cow testing associations that bulls with Advanced Registry records had higher-producing daughters than bulls without Advanced Registry records. It was also found that since the cows mated to bulls with Advanced Registry records were higher producers than those mated to non-Advanced Registry bulls, the increase in production of the daughters over their dams averaged less for the former group than the latter. Only small fractions of the superiority of the ancestors of a bull could be transmitted to his progeny. However, it was held desirable to consider ancestors' performance in the selection of a sire.

In studying the accuracy of different records as an indication of the productive capacity and transmitting ability of cows selected for breeding purposes, the Iowa station concluded from correlations between different records made in Herd Improvement Registry lactations that the high correlation between a cow's highest record and the average of the other records from which this one was selected resulted from the statistical effects of the selection itself and did not indicate superiority of the highest record for predicting future production or breeding value. In fact, the correlation of the highest record with other records from which it was not selected was less reliable than the average of all unselected records as an indication of the productive value and transmitting ability of the cows. Averages seemed more dependable for indicating differences between cows than any single record.

Evidence derived by the California station in a breeding program with dairy cattle indicated that sire families can be obtained in which all of the female offspring have superior germ plasm for production. A total of 490 dam-daughter comparisons indicated that the average milk and butterfat production of the daughters exceeded that of the dams.

Reproductive efficiency of dairy cows.—In studies at the Oregon station the reproductive efficiency of dairy cattle was measured by determining the closeness to which the cows approached a standard based on regularity of calving at 12-month intervals after attaining a certain age, dependent upon the breed. The reproductive efficiency of dams was found to be correlated with that of their female descendants.

Grading up beef cattle.—The need for cattle adapted to southern conditions prompted the Mississippi station to determine the type and efficiency of meat production by calves from native cows sired by native, Polled Devon, Polled Shorthorn, Polled Hereford, and Aberdeen Angus bulls. Although native calves gained nearly as rapidly as grade calves during the suckling period, feeder calves, slaughter calves, and carcasses of the former group graded only Medium, whereas calves sired by purebred bulls graded Good or better.

Transmission of abnormalities in cattle.—An abnormal condition in Jersey calves involving the absence of all or part of the lower jaw, was described by the Kentucky station. This abnormality seemed to be inherited as a recessive, and since it occurred in only four males it was assumed to be limited to individuals of that sex. Two sires appeared to be heterozygous for the defect. Another lethal abnormality, in Holstein cattle, noted by the Idaho station involved an opening between the frontal and parietal bones through which brain tissue protruded.

Chromosome numbers in sheep, goats, and hybrids.—The Texas station, in cooperation with the Carnegie Institution, studied the chromosomes from amnion cells of 30-day-old embryos of goats, sheep, and hybrids, produced by mating Merino rams with Angora does. These studies indicated the most likely chromosome number for goats to be 60, for sheep 54, and for the sheep-goat hybrids 57. There were some variations in the chromosome counts attributed to chromosome fragmentation, nondisjunction, end-to-end fusion, or

other irregularities. The four largest chromosomes of the sheep had a characteristic shape and were larger than any in the goat. Death of the hybrid embryos at two-fifths of the gestation period may be due to unbalanced chromosome relationships.

Breeding practices in producing pure breeds of livestock.—Continuing the study of breeds, analyses were made by the Iowa station of inbreeding and relationship in Poland China swine and Hampshire sheep as determined from herdbook records. The breeding systems used were much the same as for the other classes of livestock previously studied. The amounts of inbreeding were small, the reduction in heterozygosis per generation being less than 1 percent. Only a slight tendency for the breeds to separate into families was noted, and no single individuals were predominant in either breed. The average interval between generations was about 3.6 years for Hampshire sheep and 2.5 years for Poland China swine.

Horns in sheep.—In an investigation at the Texas station of the inheritance of horns and hornlessness in sheep, it was found that the horns of males and knobs of females in the fine-wool breeds depend for their inheritance on the same pair of major genes found in the mouflon, one of the ancestral species of domestic sheep. The gene for horns is recessive to the gene for hornlessness. The major gene for horns carried by the Dorset belongs to the same allelic series. This gene is the same as that for horns in the Rocky Mountain Bighorn.

Color in sheep.—Studies at the Texas station indicated that there are at least two different recessive genes for black in sheep, either of which may produce black. One of these genes is carried by the wild mouflon as well as by various domestic breeds. In fact, one of the genes for black was found in the Romney, in which black is extremely rare.

Morphological characters in sheep and goats.—The production by selection of tailless sheep, at the South Dakota station, progressed so that of 64 lambs born in 1938 none required docking. Ten of thirteen crossbreds with Southdown grade parents had tails averaging 3.1 inches and 2 had no tails.

Dominance of genes for freedom of skin folds in Rambouillets was indicated in studies at the Texas station, also that type of lock in Angora goats, i. e., flat lock or ringlet, has little effect on the quantity or quality of the scoured mohair produced.

Cross-breeding for pork production.—An analysis of data from more than 1,000 crossbred and purebred pigs involving the Poland China, Duroc-Jersey, Yorkshire, and Danish Landrace breeds at the Iowa station, in cooperation with the Department (B.A.I.), showed that crossbred pigs were more vigorous from birth to weaning, averaged heavier in weight, litters were larger, and gains were more rapid with a smaller feed requirement per unit of gain than purebreds. Further, the crossbred sows were efficient pork producers when backcrossed to one of the parent breeds or when crossed with a third breed, and the pigs compared favorably with those of the first cross. The conclusion was stressed that crossbred sows must be mated with a purebred boar if satisfactory results are to be obtained.

Morphological characters in swine.—The Michigan station found that longer carcasses of pigs were associated with larger numbers of

vertebrae. Breed differences in this respect were noted, but the sexes did not differ significantly. More than one pair of genes seemed to be responsible for vertebra number. The Idaho station found that the inside toe of swine is usually shorter than the corresponding lateral toe of each pair of digits. Much variation was observed. When pronounced the condition tended to cause lameness. The abnormality seemed to be inherited. Reasonably normal sows and boars frequently produced some defective pigs.

A single recessive gene seemed to be responsible for a hydrocephalous condition in swine studied at the California station. This hereditary factor also caused light coat color and short tails.

Breeding for disease resistance and viability in poultry.—Three inbred lines of poultry showing marked differences in resistance to fowl typhoid were developed in more than 10 generations of breeding at the Iowa station. X-ray irradiation of the chicks appeared to lower resistance to certain diseases while the number of leucocytes was decreased as a result of such treatment. Six years' breeding from families with high livability reduced mortality approximately one-half in studies at the Pennsylvania station. At the same time egg production in Single Comb White Leghorns was increased without significant changes in egg weight and body weight. Although there was some loss in egg weight in Barred Plymouth Rocks in 1933-34 this loss was recovered through subsequent selection.

Selective breeding based on mortality in the laying house was effective at the Massachusetts station in reducing mortality in Rhode Island Reds through three generations. Combined mortality from fowl paralysis and leukemia was reduced over a 5-year period from 24.1 to 6.9 and mortality from all other causes decreased from 20.5 to 10.7 in studies at the Idaho station. These findings demonstrated that, although a certain amount of natural resistance to disease may follow normal breeding operations, a selective breeding program can accomplish definite results in reducing mortality due to a complexity of diseases. The use of old hens as breeders, particularly from families having good livability during their first laying year, and the use of old cock birds having a large number of sisters in laying houses with little or no mortality prior to the start of the breeding season, proved an effective breeding practice. Progress was reported in a study at the New York (Cornell) station on the transmission of disease resistance and susceptibility to high temperatures in White Leghorns, Rhode Island Reds, and crosses between them.

The North Carolina station found adult mortality arising principally from noncontagious factors to vary from family to family from no mortality to approximately 50 percent. Over 20 percent of the daughters of one male died from prolapse of the uterus during the first year, and in some families nearly all of the chicks from 4 to 8 weeks of age died after having been subjected to measured doses of coccidiosis.

The Western Washington station developed lines of Single Comb White Leghorns that were relatively more resistant or susceptible to diseases, particularly of the leucosis complex, than other strains. Pullet laying-year mortality was reduced through 8 years of breeding from 83 percent for the progeny of the first year to about 35

percent for that of the eighth year. Average survival was increased from 270 to 478 days per bird.

Cage methods of producing poultry.—Hens confined in cages and bred by artificial insemination and stud mating were compared at the New Jersey station. Through artificial insemination once in 10 days, 80 percent fertility and 75 percent hatchability were obtained, with a considerably smaller number of males required. Thus, the possibilities of stamping the desirable traits of a chosen sire upon a given strain of fowls were much enhanced. Stud mating with a sire at periods of approximately 1 week was time-consuming and materially reduced the number of hens to which a single sire could be mated.

Reaction between genetic and environmental factors in turkey production.—The California station found environment to be especially important in the expression of genes causing a condition known as pendulous crop in turkeys. At Tomales, Calif., with a mean maximum temperature of about 74° F., high humidity, and little sunshine, the condition was unknown; but at Davis, where the mean maximum temperature was 20° higher, with more hours of sunshine and lower humidity, from 50 to 100 percent of the birds in the same lines developed the pendulous-crop condition.

A similar effect of environment was noted by the Kansas station in connection with the formation of crooked keels in chickens. Although inherited, the occurrence of this condition was influenced by the sharpness of the perch, the age of starting the birds to roost, and the amount of time spent on perches. Crooked-keel strains showed an incidence of from 60 to 80 percent of crooked keels under normal housing conditions. Affected birds were not more susceptible to rickets, even on deficient diets, than straight-keeled birds.

Breeding for egg and meat production.—Marked success in breeding for improved egg production, size, shape and color, and characteristics of the shell and albumen was reported from the California station. Sires from certain inbred families of White Leghorns produced at the Iowa station proved superior to other sires for improving fertility and hatchability of the eggs and viability of the chicks produced in crosses with hens of other families. In general, top-crossing of inbred sires on random-bred females gave better results than random breeding or inbreeding.

The Hawaii station found that hybrids produced from crosses of Japanese Shamo Game sires mated with Barred Plymouth Rock, Rhode Island Red, and Single Comb White Leghorn hens were generally superior to purebreds in rate and economy of gains. The carcasses of the hybrids had a better appearance than those of the purebreds. Progeny of the Shamo Game × Leghorn lacked dark pin-feathers and all had pea combs.

Growth constants in domestic fowl.—A statistical study at the California station of growth constants from crossbred fowls gave evidence of the action of sex-linked factors. Decreased early growth rates of late hatches were followed by compensatory growth at later dates. The growth curve of the chicken embryo was found to give a satisfactory fit to a straight line after 7 days, but it was chiefly accelerated in growth rate between 13 and 17 days of age. Distortion in the straight line was noted in embryos incubated at 105° or at 90° F.

Morphological characters in poultry.—Five types of cross beak in fowls were described from the Connecticut (Storrs) station, two of which seemed to be hereditary. Although cross beak was not lethal, mortality after hatching was heavy because of difficulties experienced in eating. Although two of the types were evidently hereditary, their mode of inheritance was complex.

A study of the variance in the tarsometatarsal length of domestic turkeys at the Oklahoma station indicated that heredity was responsible for about 25 percent of the variability in males and 39 percent in females. The shank length in females, therefore, served as a better measure of breeding progress than that of males.

Heredity of earliness of sexual maturity in turkeys.—The California station found that early sexual maturity in turkeys is hereditary. Selection made possible the production of hatching eggs earlier than in nonselected, late-maturing strains. This is important since a considerable portion of the early turkey egg production is sold for hatching.

An autosexing strain of poultry.—The natural sex dimorphism in color of Barred Plymouth Rocks is greatly accentuated when the sex-linked barring gene and the autosomal gene for mottling are incorporated within a strain, because the female carries only one gene for barring, whereas the male carries two. By crossing mottled Ancona hens with Barred Plymouth Rock cocks and selecting from the progeny those homozygous for barring and mottling, the New York (Cornell) station showed that a strain could be produced in which the chicks having a black head spot and black down on the back were females, whereas those lacking a head spot or having dilute black on the backs were males. It was suggested that such a strain homozygous for mottling could be freely outcrossed with Barred Plymouth Rocks to acquire a high level of productivity and would continue to show the sex dimorphism in color.

Sexual dimorphism in the down color and adult plumage of geese.—The Alabama station described a strain of geese in which adult males were white with few gray feathers and sky-blue eyes. The plumage of females was predominantly gray, with dark-gray or brown iris color. The down color of goslings was lighter in males than in females.

Position of bird embryos failing to hatch.—The Minnesota station classified the types of embryos found in eggs failing to hatch during incubation. Malposition involving the head under the left wing occurred in about 20 percent of the late dead embryos in eggs over 60 gm. in weight, as compared with less than 4 percent in eggs under 52 gm.

In a study of turkey, chicken, pheasant, and partridge embryos that failed to hatch, the California station found no significant species differences in position. Embryos rarely pipped the shell when the head was to the left or between the thighs, regardless of the end of the egg in which the head was located. Turkey embryos were handicapped if the head was in the small end of the egg, and larger numbers were in this position when the eggs were incubated horizontally than when the large end was up. Hereditary factors seemed concerned with the position of the head to the left in chicken embryos.

Hormone relations to gene expression.—An example of the influence of the male and female sex hormones on feather color and struc-

ture was found in the work of the New York (Cornell) station. Plucking the feathers from one side of the mature male progeny from Barred Plymouth Rock roosters and Silver Spangled Hamburg hens and treating the plucked birds with Progynon-B caused the newly developing feathers to be female in structure and barred throughout. The feathers on the side that was not plucked were irregularly white and spangled as normally found in males of this cross.

Inheritance of melanism in pheasants.—The New York (Cornell) station in several crosses with ringneck pheasants of a melanistic mutant, which was primarily black throughout, showed melanism to be due to a single dominant autosomal gene. Modifying factors were needed to induce the maximum expression of the melanistic factor.

Linkage of pea comb and blue egg in the fowl.—The New York (Cornell) station has found linkage to occur between the factors for pea comb and blue egg in the fowl. All of the single-comb daughters produced by mating an Araucana rooster, a blue-egg strain, with domestic hens laid white eggs, and all but two of the pea-comb progeny laid blue eggs. It was estimated that 6 percent of crossing over occurred between these genes.

PHYSIOLOGY

Physiological studies relating directly to reproduction and lactation were continued with respect to the role of endocrines in domestic animals and poultry. Increased interest in artificial insemination presented problems on preservation of semen and the most opportune time for conception in the female.

Studies on egg formation.—The Kansas station investigated the formation of egg white in the magnum of the oviduct. Histological and chemical studies were made of oviducts removed from birds with eggs in various stages of formation. Egg white was formed continually in the glandular cells of the magnum and stored in the cells and in the tubular glands. As the egg travels down the oviduct the egg white is forced out of the cells of the glands and surrounds the egg. The amount of white deposited in a given egg varied with the length of time since the preceding egg traveled through the oviduct. A decrease in egg size accompanied increased laying intensity unless the rapidity of forming egg white was increased.

Artificial insemination.—Artificial insemination of cattle has been studied at the Missouri, Minnesota, Nebraska, New York, Wisconsin, and other stations. These investigations have been so productive of results that cooperative artificial breeding associations have been formed by breeders in nearly 20 States. The principal advantages of such associations are effectiveness of disease control, reduction of cost, and improved efficiency in the greater utilization that may be made of single sires of outstanding merit. The Missouri station showed that 1.4 services were required per conception by artificial insemination as compared with 1.5 services by natural methods. Difficult and shy breeders were more readily settled by artificial insemination. Although semen stored 18 days at from 40° to 50° F. showed approximately 90 percent motility, no conceptions were obtained with semen stored more than 48 hours. Various methods for semen collection have been investigated. The Idaho station in cooperation with the Department (B.A.I.) continued studies on shipping ram semen long

distances. So far, five ewes have produced healthy lambs when fertilized with semen collected and shipped approximately 2,600 miles from Beltsville, Md. A temperature of 5° C. was maintained in transit.

Quality of semen for insemination.—Although motility may be maintained, semen samples vary materially in their viability for use in artificial insemination. This fact prompted the Minnesota station to study the glycolytic power of ram semen. The decreases in the amount of reducing sugar brought about during a standard incubation period and the carbon dioxide production at room temperature by uniform amounts of sperm showed that much of the variation in the rate of decrease in the motility of different samples was associated with variations in the glycolytic power of the semen. This test seemed to offer promise both as a standard for testing decreases in viability of semen samples and as a comparative test of different sires.

In studies with fowl semen the Kansas station found that neither sperm concentration nor morphology was an accurate means of detecting males that produced semen of poor quality. There was almost as much difference between the comparative density of two samples from the same male as between different males. Variations in sperm counts seemed to bear no direct relation to fertility, but a decline in density was noted in birds with the lowest fertility. Some males showed a high percentage of abnormal sperm, whereas others that were sterile in normal matings and had morphologically normal sperm proved fertile when used for artificial insemination purposes.

Influence of feed on sperm production of jacks and stallions.—A ration composed of 6 to 7 parts of oats, 2 to 3 parts of wheat bran, and 1 to 2 parts of crushed wheat with 1 ounce of oystershell flour daily proved superior to a ration of corn alone in its effects on sperm production by stallions and jacks in studies at the Mississippi station. Sperm concentration, number of sperm, and the volume of the ejaculates were increased by approximately 300 percent, and the physiological quality of the spermatozoa, survival period in storage, and resistance to diluters were also enhanced. It was recommended that the complete ration, to become fully effective, should be started at least 1 month before the beginning of the breeding season. The same station also found it possible to store stallion and jack semen of high concentration and high viability for an 8-day period when diluted with equal parts of a glucosetartarate diluent and kept at 45° F. The survival period of such stored semen in the female genital tract decreased with the increased storage period so that several inseminations were necessary per heat period.

Prenatal and postnatal sex ratios.—The Pennsylvania station found less than 1 percent excess of males over females among nearly 1,000 lambs born in the station flock and nearly 1,000 fetuses of various ages recovered from packing plants and other sources. No significant differences in sex ratios of embryos at varying ages were observed. On the other hand, the Wisconsin station found an excess of males in cattle fetuses at younger ages.

Interaction of genes and diet in rats.—The Michigan station, in experiments with rats, found that the frequency of occurrence of a

characteristic curvature of the nose among the progeny of bent-nosed parents varied from less than 1 percent on a well-balanced ration to 65 percent on a low-calcium ration. The results obtained from the use of several different diets led to the conclusion that the calcium:phosphorus ratio was the deciding factor in the occurrence of the condition in strains with bent-nose genes. Supplements of vitamin D reduced the deleterious effects of the deficient ration. More than one pair of genes seemed responsible for the condition when the diet would permit its expression.

Hormone relation in lactation.—The Missouri station has conducted extensive studies of the relation of pituitary hormones to milk secretion and has described a method for separating the carbohydrate-metabolism hormone of the pituitary from the lactogenic hormone. The Nebraska station found the highest lactogen content of the pituitaries in three groups of rats within 51 hours after parturition, with rapid decline in a group that suckled their young. It was suggested that the lactogenic hormone plays no major role in determining the height of the lactation curve, but it may be concerned in the rate of decline in milk production. Mammogen, the pituitary hormone concerned in the preparation and growth of the mammary gland, was found by the Missouri station to differ significantly in chemical composition from the lactogenic and carbohydrate-metabolism hormones also found in the pituitary gland. Mammogen was extracted with lipide solvents and remained in solution with high concentrations of alcohol. A method was proposed for mammogen assay based on the gland development induced in immature male mice. In studies at the New Jersey station oestrogen injections were found to increase the lactogen content of the pituitary glands of ovariectomized female rats. Injections of 200 to 1,000 International Units of Progynon-B increased the pigeon crop-gland units of lactogen about 40 percent with the smaller dose and about 28 percent with the larger dose. The pituitaries from ovariectomized rats injected with this hormone were significantly larger than from rats with ovaries intact and similarly treated.

Gonadotropic hormones.—The gonadotropic hormone potency of serum from pregnant Welsh ponies was found by the California station to be very high, especially at 60 to 75 days after conception. By the use of pregnant-mare serum, pregnancy was accurately diagnosed in 90 percent of the mares tested by the Maryland station 40 to 80 days after breeding.

Oestrus was induced in milk goats during the anoestrous period by the Ohio station following injections of gonadotropic substances.

Sexual behavior of cockerels.—The Missouri station observed the numbers of matings of cockerels after 36 hours of sexual rest, and collected and studied semen samples for each complete mating during a 15-minute period. The mean volume per ejaculate was 0.3 cc. with a mean concentration of 2,320,000 sperm per cubic millimeter. The frequency of matings varied at different periods of the day, but was greater in the late afternoon than in the morning.

Fundamental physiology of mammary glands.—Differences in the composition of the venous and arterial blood in lactating goats observed by the Missouri station, frequently showed the mammary gland to be in negative nitrogen balance. Variations in the nitrogen

content of the milk from time to time were sufficient to mask the amount of nitrogen actually involved in milk secretion. The Minnesota station found that differences in the protein tissues of active and inactive mammary glands were reflected in physical properties rather than in differences in amino acid composition. Biochemical analyses of mammary glands showed that rather large quantities of free fatty acids were present in actively secreting glands, while resting glands contained much smaller amounts or only traces. The free fatty acids did not occur as particles but apparently were present in the molecular or colloidal state.

ANIMAL DISEASES AND DISORDERS

HORSES

Equine encephalomyelitis.—This is perhaps the most important disease with which the horse industry is faced at the present time. The Nevada station points out that antiserum of high virus-neutralizing titer will be needed for some time as an aid in the treatment of clinical cases of the disease. Even after a prolonged course of immunization by subcutaneous injection of the virus the response was poor or variable and the serums of only a few animals attained a titer considered satisfactory for clinical use. A single intravenous injection of a large dose of the virus into immune horses resulted in a tenfold rise of antiviral titer in 10 days, with no unduly severe reaction. The Montana station made observations on two outbreaks of the disease. In the first, two strains of the western virus were discovered and identified, but all attempts to establish the identity of the causative agent in the second outbreak failed. At the Colorado station the mosquito (*Culex tarsalis*) failed to transmit the virus of equine encephalomyelitis from infected to normal guinea pigs.

"Walking" disease of horses.—The Washington station obtained definite indication that this disease, characterized by marked hepatic cirrhosis, was caused by the consumption by horses of the seeds of the Walla Walla tarweed, also known as the yellow burweed (*Amsinckia intermedia*).

Control of internal parasites.—Experiments with horses conducted by the New York (Cornell) station indicated that 32 percent of strongyle eggs overwintered successfully on pasture in normally deposited manure. When the manure was spread in a thin layer, all of the eggs were killed. Rotational grazing of pasture plats coupled with chain harrowing to spread the manure on each plat at the time horses leave it should provide an effective and practical means of control.

"Bloat colic" in Puerto Rico.—According to the Puerto Rico station, this disease of horses is the cause of many losses. In studying the relation of internal parasites to the disease, 24 species of nematodes were identified from 1 typical fatal case. Three species of *Habronema* and 1 species of bot were found in the stomach, and 3 species of large strongyles, 2 species of oxyurids, and 16 species of the small strongyles were recovered from the cecum and colon. The mucosa of the small intestine, cecum, and colon were very much inflamed and the wall of the cecum was thickly studded with small strongyles. So far as could be determined the colic appeared to be caused by something other than the nematode infestation.

SHEEP

Dysentery of newborn lambs.—This affection of newborn lambs, as it occurs in northwestern United States, according to findings at the Montana station, is the result of several factors rather than a specific infectious disease caused by a specific pathogenic micro-organism. The factors are low temperatures, causing lowered vitality; unsanitary conditions of lambing sheds and corrals; and the presence in the environment of strains of intestinal bacteria which are potentially pathogenic. Attempts to control the disease with antiserums prepared by the use of *Escherichia* cultures recovered from lambs dead of dysentery produced unsatisfactory results although they were not entirely without effect. Treatment of affected lambs with intestinal antiseptics proved of some value when the treatment was started early.

Urinary calculi.—While the causative factors of urinary calculi remain to be definitely determined, experience at the Colorado station indicates that they are more prevalent during the winter, and when the animals are on a dry roughage deficient in vitamin A and high in phosphates. A change of ration to corn and alfalfa usually resulted in a cessation of outbreaks. Male lambs fed a ration of sweetclover silage and grain at the North Dakota station developed mild cases of urinary crystals and calculi.

Breed resistance to internal parasites.—Groups of lambs representing five breeds of sheep were kept on an irrigated pasture for 12 months by the California station, and continuously exposed to infection from *Ostertagia circumcincta*. Statistical analysis of egg counts made every 2 weeks as an indication of relative resistance or susceptibility showed that the different breeds varied in susceptibility in ascending order as follows: Romney, Rambouillet, Southdown, Shropshire, and Hampshire. The three latter breeds possessed a susceptibility of approximately the same magnitude. The Romneys were outstandingly resistant, there was no significant difference in the susceptibility of individuals in the Romneys, but there was a wide variation in the susceptibility of individuals of the other breeds. The more resistant individuals of the more susceptible breeds possessed a resistance of approximately the same magnitude as the mean of that of the Romney. This finding makes it theoretically possible for a breeder to develop a resistant strain within any of the more susceptible breeds.

Internal parasites of lambs.—The Colorado station found the number of coccidia in the intestinal tract of lambs to rise gradually for at least 1 or 2 weeks, remain stationary for a period of about 3 weeks, and thereafter undergo a fairly rapid decline. The first month appeared to be the period during which coccidiosis may develop. Even in lambs kept under ideal conditions, coccidia became sufficiently numerous to approach the danger point. When coccidiosis did develop it was usually found that lambs were closely confined, and in some cases improperly bedded, while a majority were being fed a heavy ration.

A method for preparing a stabilized concentrate of copper sulfate and nicotine sulfate with the protective colloid gum arabic has been described by the Wisconsin station. No precipitation was found to occur either in the concentrate or in the fluid prepared for drenching

sheep for internal parasites. It was also found that the stabilized concentrate can be stored or easily transported, and by proper dilution accurate dose potency assured.

Infectious necrotic hepatitis.—This affection, also known as black disease, according to the Montana station, is manifested by sudden death from toxemia produced by the activity of *Clostridium oedematiens* in the liver following invasion by immature flukes. Work carried on simultaneously with similar investigations in Australia resulted in the development of an alum-precipitated toxoid prepared from a highly toxic strain of *C. oedematiens* that prevented the disease in infected areas.

Overeating by fattening lambs.—Investigations at the Colorado station revealed that 45 percent of intestinal filtrates from 256 lambs dead of overeating were toxic for laboratory animals. Twelve of twenty filtrates proved fatal to sheep when injected in amounts varying from 5 to 50 cc. Heating to 60° C. for 30 minutes rendered the filtrates harmless. While overeating seemed to differ from enterotoxemia on the basis of symptoms and lesions, the intestinal contents of lambs dead of the 2 diseases contained toxic substances that seemed to be identical.

CATTLE

Bang's disease (infectious abortion).—Vaccine, consisting of suspensions of living *Brucella abortus*, United States Bureau of Animal Industry strain 19, was successfully used by the California station to eradicate Bang's disease from a badly infected dairy herd. The association of vaccinated with healthy nonvaccinated cattle did not result in any spread of strain 19 to the latter. It was observed, however, that the resistance produced by the vaccine may easily be overwhelmed by exposure to massive infection; therefore, sanitary precautions are necessary for its successful use. No apparent injury resulted from the vaccination of three heifers while between the third and fifth months of gestation. Vaccination of an isolated cow during advanced pregnancy brought about a typical brucellosis, with death of the fetus, and discharge of large numbers of the organisms of strain 19 in uterine material at the time of parturition.

Inoculations of cows reacting to *B. abortus* tests during the open periods were found by the North Dakota station to lengthen the time before conception was obtained, and a greater number of services were required per conception when compared with animals not inoculated during the open period. Bang's reactors that were inoculated with *B. abortus* during the gestation period produced 10 dead calves and 36 live calves. On a percentage basis these were divided quite evenly between those inoculated and those not inoculated during the preceding open period, and the percentage of retained fetal membranes was about the same in the two groups. The experiment indicated that there was no absolute immunity in Bang's disease.

Mastitis of dairy cattle.—An intensive study by the Idaho station of the use of sulfanilamide as a treatment for mastitis showed the drug to be a valuable treatment for the disease but one that must be used with caution. Total daily doses of 5 gm. per 100 pounds of body weight, administered in capsules of two or three equally divided and equally spaced doses for a period of 5 to 7 days, gave satisfactory

results in the treatment of most new acute cases of mastitis. Some improvement in relieving the acute symptoms of old cases occurred when sulfanilamide was administered as above. During the course of the treatment, it was found that cows should be kept quiet, out of the sun, and the dosage reduced or discontinued if they go off feed or show other toxic symptoms.

In studies to determine the reliability of indirect biochemical tests (chlorides, catalase, and pH value) for the detection of chronic contagious mastitis, the Wisconsin station, working with the Dominion Department of Agriculture (Canada), found that infected quarters not infrequently yielded normal milk while many noninfected quarters yielded milk giving definitely abnormal reactions. The reactions to these tests frequently fluctuated widely from milking to milking from both infected and noninfected quarters. These findings suggest the need of caution in the use of such tests as the basis for diagnosing mastitis. They emphasize the value of examining a series of samples at consecutive milkings in order to obtain a true picture of the condition of a quarter. Of the three tests studied, the catalase test appeared to be the most sensitive indicator of infection.

Studies of tests for the detection of mastitis at the Kansas station showed that the bromothymol-blue test, although rarely giving a false reaction with a known negative cow, failed to detect a sufficiently high percentage of the positive cases to recommend it as a sole means of identifying mastitis for segregation purposes. The fact that high leucocyte counts above the arbitrary standard of 500,000 per cubic centimeter were found in only 36.7 percent of the samples actually containing long-chained streptococci suggested that this standard may be too high for proper interpretation. Long-chained streptococci were not detected in 14.7 percent of samples taken only from involved quarters, emphasizing the necessity of making repeated analysis for effective diagnosis. Leucocyte counts above 100,000 per cubic centimeter and the appearance of streptococci in chains of only medium length were frequently found to give forewarning of impending mastitis.

In observations on the behavior of known cultures of streptococci of bovine origin the Connecticut (Storrs) station found that Edwards' medium was about 95 percent effective in separating *Streptococcus agalactiae* from other types of streptococci found in freshly drawn milk. The ability of the medium to inhibit the growth of staphylococci contained in large numbers in incubated samples aided materially in detecting the presence of *S. agalactiae*. In an attempt to correlate certain properties of udder staphylococci with other laboratory evidence of mastitis, it was shown that ability to coagulate human blood plasma was more closely correlated with accepted laboratory evidence of mastitis than any other test for staphylococci employed.

At the Michigan station cows subjected to experimental exposure of a typical strain of *S. agalactiae* recently isolated from a case of chronic mastitis became infected only after repeated dipping of either the uninjured or the injured teats into the culture. When the teats were injured sufficiently to draw blood, infection developed as a result of one dipping. Repeated exposure of the cows to the streptococcus per os, or by the subcutaneous or intravenous routes, did not result in streptococcic mastitis. One cow in the experiment became infected as a result of being stabled in the same barn with infected cows.

Bronchopneumonia in cattle.—Studies by the Florida station have shown bronchopneumonia to cause heavy losses among calves under 6 months of age confined in crowded, unsanitary, permanent lots. The mortality from this disease frequently amounts to 60 or 70 percent of the annual calf crop, and further loss is sustained because the animals that survive the infection are undeveloped, unthrifty, and unprofitable. *Escherichia coli*, *Pasteurella bovis septica*, and species of *Staphylococcus* and *Penicillium* were found to be associated with the condition. Older calves affected with the chronic form of the disease were found to be infested with a host of internal parasites, and the blood-sucking louse *Linognathus vituli*. No single predisposing factor was found that reproduced typical bronchopneumonia as observed under field conditions.

Low phosphorus diets.—In studies at the Utah station it was found that aphosphorosis existing in herds of dairy cows where parturient hemoglobinemia occurred, was probably due to a low intake of food phosphorus. Cows affected with parturient hemoglobinemia made rapid recoveries following intravenous administration of sodium phosphate supplemented with drenches of this salt or bonemeal. The Wisconsin station discovered that stones consistently obstruct the urinary tracts of young rats in the laboratory kept on a synthetic low-phosphorus diet containing abundant vitamin D. Rats grew and reproduced in good health for several generations when phosphorus and vitamin D were added to the basal diet.

Anaplasmosis in cattle.—The Kansas station, in cooperation with the Department (B.A.I.), found that iron, manganese, and copper built up the hemoglobin content of the blood but did not increase the animal's resistance to anaplasmosis. The blood of "carrier" or recovered animals retained the ability to transmit the disease as rapidly as blood taken from acute cases of anaplasmosis, but carrier or recovered animals were resistant to infection. Calves inoculated with infective blood seemed to acquire resistance to anaplasmosis and become carriers. The inoculation of ground lice taken from an animal sick with anaplasmosis did not reproduce the disease in a susceptible animal. Formalin in a concentration of 0.1 to 0.5 percent added to virulent citrated blood destroyed the infectivity of the blood but such blood failed to immunize cows. Urotropin was not an effective agent for treating the disease, and thymus extract, heated or unheated, had no protective value. The intravenous injection of hydrochloric acid (1 to 1,000) was of no value in reducing the virulence of the blood of carrier animals. Atebrin and plasmochin failed to demonstrate any efficiency in relieving the carrier state or in the treatment of acute cases. Cattle treated with 2-percent mercurochrome within the third day after the initial temperature rise showed prompt response and recovery. Mercurochrome established a purging action that seemed to be entirely desirable, but did not alter the carrier state. Fuadin was not of therapeutic value in the treatment of one acute case.

Experimental work conducted cooperatively between the Oklahoma station and the Department (B.A.I.) showed that both the male and female *Dermacentor andersoni* ticks may transmit anaplasmosis in cattle, and that it is transmitted by naturally infected ticks.

Toxic plants.—Confirmatory evidence to indicate that oat hay produced in certain areas of the State exerted a strongly toxic effect on cattle was secured by the Wyoming station. Eleven pounds of toxic

hay caused the death of a 350-pound steer 9 hours after feeding, while a water extract of 11 pounds of the hay caused typical symptoms in another steer of similar size. In each instance a high methemoglobin content of the red blood cells was observed.

Serious losses among cattle that followed the feeding of oat hay, weedy barley hay, and wheat straw were reported by the Colorado station. In all but two of the cases observed the hay was fed when damp. The symptoms were suggestive of hydrocyanic acid poisoning, but in only two instances was a trace of this substance found in the hay. When the oat hay responsible for one outbreak was fed experimentally to six cattle, all died showing symptoms and lesions typical of oat-hay poisoning. The rumen content of four of the six animals showed positive tests for hydrocyanic acid by the sodium picrate paper method. Aqueous, alcoholic, acid, and alkaline extracts of the offending oat hay were harmless when administered to laboratory animals.

In the course of a survey to determine the cause of unexplained cattle losses in the northeastern part of the State, the Colorado station found that *Suckleya suckleyana* was responsible. This plant has become rather common in the area in moist bottoms and water holes, and along the edges of lakes. Both chemical analysis and feeding tests proved the plant to be cyanogenic. Tests for hydrocyanic acid were positive for every specimen examined, the concentration varying from 0.0364 to 0.002 percent as compared with 0.0135 percent in a sample of stunted cane. When force fed, the sample having the highest hydrocyanic acid content proved toxic for cattle, sheep, rabbits, and guinea pigs.

POULTRY

Fowl paralysis.—The Iowa station demonstrated that it is possible through selection to develop strains of chickens resistant or susceptible to fowl leucosis. The causative agent was shown to be extremely virulent, the progeny of seven of the eight matings used being equally susceptible to the disease whether injected with the virus or simply exposed to the disease by contact. The progeny of individual hens were found to be quite variable in their resistance or susceptibility.

Experimental attempts by the New York (Cornell) station to transmit fowl paralysis to normal chickens by means of intraneural implantation of affected nerve tissue and by means of cross circulation of the blood between a diseased and a normal bird met with uniform failure.

A transplantable lymphoid tumor, similar in certain characteristics to the lymphocytoma common in chickens, has been maintained for 28 serial passages in experimental chickens at the Massachusetts station. Repeated attempts to demonstrate a cell-free agent in association with the tumor have been negative. Birds bearing this tumor, those recovered spontaneously, and those resistant to an initial inoculation have been resistant to a second or repeated inoculations.

A new fundamental principle of self-perpetrating tissue autolysis is described by the Florida station as the basic process involved in experimental leukemia in the chicken and other domestic animals. Tissue autolysis leading to leukemia was initiated by the intravenous injection of living and heat-killed species of paratyphoid and typhoid groups in the chicken, dog, monkey, hog, goat, and sheep; autolyzed

homologous tissues in the chicken, dog, monkey, and goat; and chemicals (benzene, phenol, and xylol) and suboxidation in the chicken. The fundamental nature of the process was similar in all instances. The analogies of leukemia and carcinoma are enumerated, and the hypothesis is advanced that the principles of tissue autolysis which concern blood cells in leukemia are involved in carcinoma, in which the process is confined to cells of fixed tissue.

Studies of an indistinct or dull-eyed condition in a flock of White Leghorns at the Utah station indicated that the infective agent produces pathological changes in at least a part of the hematopoietic organs to the exclusion of direct nerve tissue involvement. The results through two generations do not suggest the transmission of the disease through the egg from dam to daughter. Iritis-infected hens were not necessarily progenitors of lymphomatosis, and the progeny of such birds showed a lower incidence of the disease than was exhibited by the rest of the flock.

Fowl coryza.—The injection of a fresh solution of 15-percent argyrol into the infraorbital sinus of White Leghorn chickens suffering from fowl coryza failed to give any evidence of a curative value of this drug at the California station. In growth studies of the fowl coryza bacillus the need of the X factor for the growth of the Rhode Island strain was revealed at the Rhode Island station through the failure of the organism to grow in yeast extract or yeast suspensions at the base of nutrient agar slants. The factor may be supplied by the addition of autoclaved blood extract, or when the medium used to inoculate the yeast extract is of blood and sufficient of the X factor is carried over in the inoculum. Growth on yeast extract prepared by boiling was poorer than on yeast extract prepared without heat. Chicken serum and boiled yeast extracts failed to support growth except when used at the base of nutrient agar slants.

Coccidiosis.—The combination of dried skim milk and wheat middlings or dried buttermilk and wheat middlings in the ordinary type of chick ration was found by the Iowa station to be responsible for a high death rate in White Leghorn chicks experimentally infected with cecal coccidiosis. Dried buttermilk of itself was also culpable when fed in the ordinary type of chick ration.

In experiments on coccidiosis of chickens the Louisiana station has shown that in cases of severe hemorrhage the tissues of the epithelial layer, the tunica propria, and submucosa are so disorganized that they are indistinguishable in sections, and blood escapes freely into the lumen. As the bird recovers from the disease the epithelium of the glands and the tunica propria differentiate but the epithelium is more or less lacking between the glands on the surface of the lumen of the cecum, depending upon the severity of the hemorrhage. In cases of slight hemorrhage the epithelium and a limited area of the mucosa are ruptured, allowing blood to escape into the lumen of the cecum. This condition is restored to normal as the bird recovers from the disease.

Avian encephalomyelitis.—The Massachusetts station transmitted epidemic tremor or encephalomyelitis to normal chicks by the intracerebral inoculation of brain suspensions prepared from affected chicks. The disease was also reproduced in maturing birds through

intracerebral inoculations. The causative agent was found to remain infective for young chicks upon a single passage through a young turkey poult. It has not been possible to demonstrate that surviving stock of an outbreak of the disease may act as a reservoir of infection. Field and laboratory evidence suggests that the infective agent may be egg-borne and that breeding stock serves as the reservoir of the infection.

Fowl parasites.—At the Kansas station immature worms of the fowl nematode *Ascaridia lineata* grown in their normal habitat were transferred into the body cavity of other chickens to see if the nematodes could feed upon tissue or lymph. Of a total of 142 live worms transferred into the body cavities of 31 chickens, 81 were recovered, of which only 16 remained viable for from 1 to 4 days. Nearly all of the worms recovered were phagocytized, encapsulated, or walled off by some portion of the fowl's body. The worms were unable to thrive outside the lumen of the intestine. The occasional occurrence of *A. lineata* in the hen's egg obviously is due to migration of the adult worm through the lumina of the large intestine, cloaca, and oviduct rather than to the entrance through the oviducal infundibulum of a migrating larva grown to maturity in the body cavity.

The Kentucky station found that oil and nicotine placed on the perches was a rapid destroyer of poultry lice. However, the same amount of free nicotine in water was equally effective. Both materials were much quicker in their action than nicotine sulfate. Six species of lice were found infesting chickens, of which the chicken body louse (*Eomenacanthus stramineus*) was probably most injurious to adult birds.

Sinusitis of turkeys.—According to the Utah station, the symptoms of this affection consist of a watery discharge from the nostrils and eyes of turkeys, followed by a swelling of the face as a result of inflammation and accumulation of mucus in the sinuses. Loss is occasioned through a pronounced reduction in weight gains rather than high mortality. Limited trials have shown that the disease can be transmitted by inoculation with sinus exudates. The use of vaccines failed to give control. The administration of a silver nitrate solution was found to be superior to other medicaments as a treatment, a 4-percent solution giving slightly better results than a 2-percent. The syringe method of draining and treating the sinus was superior to the use of the knife. The California station found that this disease could be successfully treated by injecting either 4-percent silver nitrate or 15-percent argyrol into the sinuses after the sinus exudate had been aspirated. Silver nitrate was slightly more effective than argyrol.

Paratyphoid infection of turkeys.—*Salmonella aertrycke* may produce an acute disease of young poults up to 5 weeks of age according to results obtained at the Minnesota station. This organism was isolated from infertile eggs and dead-in-the-shell embryos during the second, third, and fourth week of incubation and from the ovary and oviduct of 3 of 10 naturally infected birds.

Infectious catarrhal enteritis.—Studies at the California station revealed that infectious catarrhal enteritis caused heavy mortality in turkey poults ranging from 2 to 10 weeks of age. In older birds it caused considerable stunting and occasionally some mortality. This disease, commonly referred to as intestinal trichomoniasis, was shown to be caused by a protozoan parasite belonging to the genus

Hexamita. Two species of *Trichomonas* found in the ceca of turkeys were without pathogenic significance. Adult turkeys were the principal means of transmission to turkey poults. A species of *Hexamita* found in quail was not transmissible to turkeys, but a species found in chuckar partridges was transmissible to poults.

GENERAL

Relation of poison dusts and baits to livestock.—The Montana station working with the Department (B.E. and P.Q.) has shown that the use of grasshopper bait does not endanger livestock when the bait is spread correctly and care is exercised in storing or discarding unused portions. There appeared to be no hazard involved in feeding crops from fields dusted with sodium arsenite for the control of Mormon crickets, provided the dusting was done in accordance with recommended practices.

Paratyphoid infection in pigeons.—An analysis of data obtained by the North Carolina station proved *Salmonella typhimurium* var. *binns* to be the etiological agent of paratyphoid in pigeons. Fresh antigens were found to be superior to preserved antigens for the detection of chronic carriers. The organism was recovered from birds consistently negative to the tube agglutination tests. The rapid whole-blood stained-antigen test could not be used for the detection of low-titer birds. In chronic carriers the organism was localized chiefly in the lungs. It was recovered from the feces, mouth fluids, and blood of squabs suffering from acute and subacute infection and from eggs laid by a chronic carrier.

Poisonous plants.—The Wisconsin station and the Department (B.P.I.) found that *Melilotus alba*, a bitter sweetclover, on being stacked at about 50-percent moisture and allowed to heat, produced a hay which, when fed to rabbits, induced a condition characteristic of the so-called sweetclover disease in cattle by markedly lowering the clotting power of the blood. *M. dentata*, a sweetclover recently recognized as being nonbitter, did not become toxic on being similarly spoiled. Neither spoiled alfalfa hay nor coumarin appeared to modify the clotting power of the blood. If, however, coumarin was mixed with partly cured alfalfa hay containing about 50 percent of moisture, the mixture on being allowed to heat became distinctly toxic. It is tentatively suggested that coumarin interacting with another constituent or constituents of the plant tissue, under conditions favorable for spoilage, gives rise to a specific toxic substance which is responsible for the sweetclover disease in cattle.

Dogbane, a common milkweed, was found by the Maryland station to be fatal to laboratory animals in comparatively small amounts. The seeds of Hercules-club (*Aralia spinosa*) were found to be very poisonous, but the foliage and the skins and pulp of the berries were not.

The Colorado station added to the list of poisonous plants found in that State *Oxytenia acerosa*, a plant containing a glucoside, and *Bahia oppositifolia*, a weed containing hydrocyanic acid.

Mechanism of the production of toxic substances.—Cultures of the *Salmonella* group of bacteria grown in broth produced, according to the New York (Cornell) station, something in the nature of a heat-stable endoenzyme which when released by natural autolytic processes or by brief subjection to 100° C. is capable of acting on the broth con-

stituents to produce certain changes characterized by a gradual increase in pH value paralleled by an increase in toxicity. These results indicate that at least a part of the poisonous substances often called endotoxin are split products of the culture medium resulting from the action on that medium of the heat-stable endoenzyme.

Action of preservatives and salts on blackleg cultures.—In studies conducted by the Kansas station anaerobic organisms proved to be more resistant to the action of disinfectants than aerobic spore-forming species. Proteolytic anaerobes were more resistant than the saccharolytic types. Iodine, metaphen, and azamine did not sterilize any of the anaerobic species tested. Phenol and formaldehyde were used for the rapid isolation of anaerobic organisms from spore-forming aerobic bacteria. Certain disinfectants when added to blackleg filtrates and bacterins increased the aggressive potency of the products, while other disinfectants had no such action. Potassium alum added to blackleg filtrates and bacterins produced a highly efficient immunizing agent for guinea pigs but did not greatly increase the aggressive activity of the products. The precipitate formed by the action of potassium alum on blackleg filtrates and bacterins contained almost the entire amount of antigenic and aggressive substances. Blackleg filtrates having an aggressive potency of 13 to 26 aggressive units reduced losses among vaccinated cattle to about 1 out of 10,000 head. Blackleg filtrates and bacterins having a potency of 30 to 130 units reduced losses to less than 1 out of 20,000 vaccinated animals.

Pneumonia in Rocky Mountain bighorn.—An investigation by the Montana station to determine the cause of losses from disease in the Rocky Mountain bighorn revealed that mortality was due to respiratory diseases of two types. A somewhat chronic pneumonia caused death principally in mature sheep, while an acute pneumonia killed lambs at an age of from 2 to 3 months. The lungworm *Protostrongylus stilesi* was found to be the primary etiological factor in the principal group of causes of pneumonia, with secondary bacterial invasion. The diphtheroid *Corynebacterium pyogenes* was the principal organism involved, although a *Pasteurella* sp. was found constantly present in the affected lungs. Parasites were not involved in the acute cases and a limited amount of work indicated that the pneumonia was primarily due to invasion by *Pasteurella* sp., with *C. pyogenes* as a secondary invader.

AGRICULTURAL ENGINEERING

CONTENTS

	Page		Page
Machinery and power.....	173	Use of irrigation water.....	177
Erosion and run-off control methods and equipment.....	176	Structures.....	178
		Electrification.....	180

Long-range planning in the use of farm land and corresponding adjustments in farming and farm life to secure permanent economic and social benefits are requiring, to an increasing extent, the rational development of engineering principles and their use in farming as an industry and as a method of living. The following discussion

cites some pertinent examples of the manner in which the State agricultural experiment stations are developing research in agricultural engineering in the interests of permanently sound agriculture.

MACHINERY AND POWER

Better use of the land and the correlated adjustments in farming practices are broadening the demand for mechanized practices developed along cost- and labor-saving lines for use on the family-size farm as well as on larger farming units. Consequently the stations have strengthened studies on the development and adaptation of mechanical equipment and on greater efficiency in the use of farm power.

Better use of tractors and engine fuels.—During 1938, according to a preliminary report of the Bureau of the Census, the number of tractors purchased by American farmers was 152,840, valued at \$116,958,500. While this was approximately a 37-percent decrease as compared with the previous year, it is significant that there was an appreciable increase in the number of rubber-tired wheel tractors. The purchase of all-purpose-type tractors continued large, particularly those equipped with rubber-tired wheels. Most of the purchases were of the lighter types of less than 30 horsepower, indicating the need for greater flexibility of mechanical power.

Under the circumstances, the stations continued their efforts to increase the efficiency of tractor operations, special attention being devoted to means for improving the efficiency of rubber tires through the development of treads and profiles best adapted to various soil types and conditions. The superiority of regular tire treads over special high-lug treads for dry soil conditions was demonstrated by the Indiana station. It was also shown that the rubber tire must have ability to flex to conform to the soil contour, and that the lug height should not exceed the point where it will penetrate the soil sufficiently to allow the body of the tire to be in contact with the soil for best results. For the types of soil and field conditions encountered throughout most of Indiana, the conventional rubber tractor tire appears to give the best results under average farming conditions. It was also found that high-lug tires permit the use of wheel-type tractors on loose, soft, and wet soils where failure occurred previously, due to excessive slippage and miring down. Studies by the Kansas station to determine the effect of wear of rubber-tire treads on tractor performance on different types of traction surfaces showed that worn tires reduce maximum traction, and that the condition of the tire tread influences the drawbar load at which lowest fuel consumption is obtained. While the range of loads through which low fuel consumption can be obtained is wider with new tires than with worn tires, at light-to-medium drawbar loads the fuel consumption with worn tires is no greater than with new tires. This would indicate that the limitation of maximum draft with worn tires is likely to be the chief factor warranting replacement of tires. Studies by the Iowa station of the life, service, and cost of service of 199 sets of pneumatic tractor tires in use on farms in 70 counties showed that the length of use ranged from 240 to 3,000 hours per year and that annual maintenance costs were very low, averaging only 28 cents per set per year. Average fuel savings were estimated at 22 percent, and the average saving

in labor at 23 percent on the basis of an average useful life of 7 years and useful hours of work of 6,765. It appears that pneumatic tires for a two-plow, all-purpose tractor represent on the average about one-fifth of the total cost of the tractor, which is somewhat less than the value of the average increase in the capacity of the tractor due to the use of pneumatic tires. This expenditure therefore appears to be well justified, at least where the proper adjustments between speed, wheel weight, and load can be made.

More efficient tillage methods and equipment.—The power load for tillage is still the largest for any of the power-consuming farm operations. In adjustments in farming practices toward greater efficiency special attention is being given to the power factor. For example, power required for plowing is 41 percent of the total required for the production of a corn crop, according to studies by the Iowa station on labor efficiency and power economy in corn production. The operation involved in secondary seedbed preparation, such as disking and harrowing, and cultivation, require an additional proportionate amount of power. Consequently every effort is being made by the stations to develop both tillage methods and equipment to reduce the power-requirement factor to the minimum commensurate with the production of a good crop. In addition, and of greater importance, are studies being made of the relationships between the metal surfaces of tillage tools and the dynamic masses of the soil. Distinct progress has been made recently by the Alabama station in establishing the effect of certain plow shapes and materials on scouring in heavy clay soils. Field and laboratory experiments with alloy-steel moldboard coverings, endless belt-type moldboards, wooden rollers replacing solid moldboards, and wooden slats impregnated with paraffin or linseed oil replacing steel slats, showed that wood-slat plow bottoms produced considerably better scouring than steel-slat plow bottoms in heavy clay soils, especially in the higher moisture-content ranges. Progress also has been made in the improvement of tools used for secondary tillage operations such as disks, notably by the Pennsylvania station, from which information has been reported on the effect of loading, depth of penetration, soil condition, and angle of operation on the proper design of disk-tool sizes from 18 to 24 inches in range.

More efficient mechanical fertilizer placement.—The use by farmers in the United States during 1938 of between 7,500,000 and 8,000,000 tons of fertilizers is evidence of the need for continued research directed to developing more efficient methods of mechanical placement.

The investigations of the North Carolina, South Carolina, Georgia, and Texas stations on the mechanical application of fertilizers to cotton were cooperative with the Department (B.A.Engin.), as were similar experiments conducted on corn and small grains by the Ohio, Indiana, Missouri, North Carolina, and Michigan stations. Between 15 and 20 other stations cooperated on studies of the placement of fertilizers on tobacco, sugar beets, and a wide variety of truck crops. These cooperative experiments which have been in progress over several years are now having a profound influence both on the methods of applying fertilizers to various crops and on the character, cost, durability, and efficiency of performance of machinery for fertilizer placement.

Better mechanical planting of field crops.—Cost of seed, labor cost of planting, and proper seed placement are primary aspects of investigations by the stations aimed at the development of more efficient methods and equipment for planting field crops. In an attempt to establish means by which seedsmen, farmers, and implement dealers may determine quickly which corn planter seed plates to use for hybrid seed corn, the Illinois station has developed a method of seed grading which indicates the proper sizes of planter-plate cells for planting corn of different kernel sizes. The Iowa station has shown that the planting of corn requires little power but much skill, and has demonstrated that it can be profitably combined with other operations. For example, tests of a four-row planter and cultivator combination indicated a labor requirement of only 0.77 man-hour per acre and a power requirement of 2.3 horsepower hours per acre. The results of 3 years of experimentation showed that planting with equipment designed to provide the single-plant hill consistently gives the highest corn yields under Iowa conditions. The utility of grass-seeding attachments on cultipackers in avoiding seeding failures was demonstrated by the Wisconsin station. Improved germination resulting from the use of cultipacker seeders also contributed to economy through use of reduced seeding rates.

Mechanical harvesting.—Many new problems in the harvesting of various crops continue to confront the stations in widespread efforts to reduce production costs. Typical station work to meet these demands is that by the Iowa station on the harvesting of corn. As a result of 5 years of experimentation it has been possible to reduce the labor for harvesting corn from 2.5 hours to 0.91 hour per acre. This has been effected through the use of pneumatic tires on tractors and wagons which permit larger loads to be hauled at higher speeds, and the use of extensible tongues for quick hitching, of larger wagons up to 100-bushel capacity, and of pit elevators which do not require the operator to wait for the ear corn to be fed slowly to the elevator. In California, where an annual average of 70,000,000 pounds of Persian (English) walnuts is produced on approximately 114,000 acres of bearing trees, the problem of harvesting and processing this crop is particularly pressing. The large size of the trees when in full bearing necessitates special equipment for the harvesting of the crop. The California station has assisted in the development of such equipment and also of equipment for processing, including hull removal, gassing to accelerate natural metabolism for hull loosening, dehydration, blending, and sacking. Approximately one-half of the crop produced in the State is sold as shelled nuts. To reduce the immense labor cost of cracking, the California station has developed a successful internal-combustion nut cracker, the essential operating principle of which is to puncture the nut shell, introduce an explosive gas mixture between the shell and the nut kernel, and explode the gas mixture to shatter the shell and separate it from the kernel. It was found that advantage may be taken of the force of the explosion to partly separate the kernels from the shattered shell by having two concentric receptacles below the flame which ignites the gas. One receives the kernel as it drops downward after the explosion and the other receives the shell which is thrown out laterally by the force of the explosion. It has

been found possible to remove approximately 60 percent of the kernels in whole or half pieces. The machine has a potential capacity of about 900 pounds of unshelled walnuts per hour.

In some States the status of dairy and livestock farming does not permit the use of other than natural curing methods for hay because of production costs. The Mississippi station has recognized this status and for several years has conducted studies on improved field methods of curing alfalfa, Johnson grass, and soybean hays. In the natural curing of these hays crushing of the stems and double windrowing reduced the time required for curing 50 percent. The stems are crushed as the hay is cut, and the hay is left in the swath for 2 or 3 hours and then is thrown into a tight, double windrow with the side-delivery rake. Johnson grass hay was cut, crushed, and windrowed in the morning and baled in the afternoon. The station has developed the principles of a satisfactory mower-crusher driven by power take-off from the tractor which requires no additional time or labor. Not only is the weather hazard reduced to a minimum by this method but the hay is of better quality and color.

In other areas where artificial curing of hay is economically feasible, particularly in the Central, Central Northern, and Northeastern States, progress has been made by the stations in the development of efficient and flexible equipment for this purpose. After several years' experimentation, an efficient portable hay drier has been developed by the Indiana station in which hay at 58 percent initial moisture content may be dried to a moisture content of 15 percent at a cost for fuel of about \$3.25 per ton of dry hay.

An example of efforts to develop efficient mechanical equipment for the harvesting of cotton by stations in cotton-producing States is found in the investigations at the California station on the revolving-finger principle of mechanical cotton picking. Fairly successful operation has been accomplished, the most serious drawback being ground shatter, which, while still high, has been reduced from 17.3 to 8.75 percent. This machine does not seriously injure the green plants, although it knocks off approximately 16 percent of the green bolls. Investigations looking toward the development of greater efficiency of the combine harvester, particularly of the smaller units having cutter bars 6 feet or less in length, were continued. With such a machine the Indiana station determined that the average total acre costs for combining 65 acres or more were less than half the costs of harvesting with binder and thresher and that less than one-fifth as much man labor was necessary. With correct machine adjustment and operation, the small combine saves a higher percentage of wheat and soybeans than the binder and thresher but does not do so well with oats. Progress has been made by the Virginia station in adapting the small combine to the harvesting of soybeans, it being found possible by use of this equipment to bring the average harvesting losses down to 12.37 percent, whereas losses with the binder and thresher are nearly 25 percent.

EROSION AND RUN-OFF CONTROL METHODS AND EQUIPMENT

Investigations to develop methods and equipment for the conservation of land and water resources for agricultural purposes have been continued and expanded at the majority of the stations, in most cases

in cooperation with the Department (S.C.S.). Progress has been made in the measurement of soil and water movement under the effect of storm run-off, and in developing the relationship and influence of the various factors involved as bases for control measures. For example, a method of measuring run-off velocity as related to soil movement between terraces has been perfected by the Alabama station. In studies of the effect of soil type, slope, and surface conditions on intake of water, the Nebraska station showed that total intake of water and infiltration rate decrease slightly with increase in slope of soil. This change in infiltration rate is very small and very gradual with changes in slope above 2 percent. Soils covered with a crop also show much higher rates of infiltration of water than bare soils, the denser crops, like native sod and alfalfa, producing the highest and longest-maintained infiltration rates. Soils covered by crop residues, such as straw or other organic materials, show even greater infiltration rates. Clay-pan soils, for example, absorb large quantities of water within a short period when the surface is protected by means of a straw mulch. The Missouri station also determined that infiltration is not affected appreciably by slope or rainfall intensity but varies inversely with the initial soil-moisture content. The Missouri station published information on the type of terrace best adapted for erosion control under Missouri conditions. This consists of a combination of a ridge of soil and a channel sufficiently wide, on moderate slopes, to be crossed easily with farm implements. The value of snow ridging to conserve moisture and decrease erosion has been demonstrated by the North Dakota station. The use of snow plows and crowders to build up ridges 18 inches high from a 5-inch snowfall resulted in holding much snow on fields, while similar areas not ridged were blown clear of snow after a thaw and freeze. With snowfall of less than 5 inches a second ridging is necessary. The best results are obtained by ridging at a temperature high enough so that the snow is damp. The ridges should not be more than 8 feet apart and should be at right angles to the prevailing wind. On rolling ground, they should be on contours. The best equipment for this purpose included a push plow driven by a large tractor capable of drawing two pull plows offset back of the drawbar. A decrease in run-off losses due to increased permeability resulting from fall and winter plowing has been shown by the Arkansas station. The addition of organic matter, winter cover, and close cropping were also found of value in reducing soil and water losses on land in crop rotation. Experiments at the Oklahoma station indicate that concrete slabs cast on the ground, in inexpensive forms, can be used to construct baffles for control of run-off water which cost less than masonry or monolithic concrete.

USE OF IRRIGATION WATER

Irrigation practices have been profoundly affected by the recurring droughts of recent years. In the semiarid regions these practices are being modified and extended to meet conditions of adjusted farming, and irrigation is also becoming of importance in some of the humid regions which have been adversely affected by droughts. Typical of

the efforts of the stations to meet these conditions are the studies at the Utah and California stations aimed at securing greater efficiency in the use of irrigation water. In cooperation with the Department (B.A.Engin.) the Utah station has demonstrated the importance where possible of measuring the volumes of water applied in each irrigation of a crop and of estimating the root-zone soil depths, the volumes of water stored as soil moisture, and the resultant water-application efficiencies. The California station found that the permanent-wilting percentage is one of the most important soil-moisture conditions influencing the effect of water-holding capacity of irrigated soils. Soils that have high water-holding capacities may be poor water-yielding soils because of high permanent-wilting percentages and consequently narrow ranges of readily available water. Soils with low availability ratios, even though they may have high field capacities, require much more frequent irrigation than do soils with similar field capacities but with high ratios and large amounts of readily available water. The station concludes that the planning of a rational irrigation schedule must be based upon knowledge of the readily available water in each soil to be irrigated.

Much has been done by the stations in developing structures and equipment aimed at the more efficient use of irrigation water. A portable meter for measuring water issuing from an alfalfa valve on a concrete pipe line has been developed by the California station. The desirable features of this meter suggest its adaptability as a general-purpose irrigation meter where water is distributed through concrete pipe lines. An acre-foot integrating instrument for use with measuring flumes on farms to indicate the total amount of water used per season for irrigation or the total acre-feet of water applied to a particular crop has been developed by the Colorado station in cooperation with the Department (B.A.Engin.).

An example in the more humid sections of work by the stations in the development of efficient irrigation practices is that of the Wisconsin station in adapting low-pressure sprinkler irrigation for truck crops and potatoes. The results show that the cost per acre for the standard type of rotary-sprinkler irrigation equipment usually decreases rather rapidly up to about 50 acres, and may be as low as \$25 or \$30 per acre on larger areas, provided the water supply is close to the field. From experience with large installations the station is proceeding toward the development of equipment peculiarly adapted to 10 acres or less.

STRUCTURES

In the adjusted schemes of farming being adopted for better use of the land, more efficient production structures are assuming an important role both on large and small farming units. Continued efforts by the stations in this direction have taken into consideration the needs of farming as a production enterprise and as a mode of living.

Better farm homes.—Comfort in farm homes is being recognized as an essential to full realization of the benefits of farm life. Attempts to enhance comfort underlie the studies of the Wisconsin and Georgia stations, in cooperation with the Department (B.A.Engin.), regarding the extent and causes of discomfort in typical farmhouses. It has

been found in the South that the greatest degree of comfort prevails in the summer in houses where the construction permits a high degree of air movement through the stud spaces and the materials are of low density which neither conduct nor readily retain heat. In the winter, on the other hand, these loosely constructed houses are the least comfortable and require greater fuel consumption to maintain given desired temperatures than do houses with tight construction. Ceiling insulation increases summer comfort in tightly constructed houses in the South and reduces fuel consumption in the winter. In three-room houses calking and weather stripping were found to reduce fuel consumption from 15 to 45 percent in low wind velocities. In connection with the utility of proper insulation in increasing comfort in both winter and summer, progress was made in developing the use of by-products of the farm as insulating materials. While not so effective for this purpose as an equal thickness of commercial insulation, cottonseed hulls treated with a solution of ammonium sulfate to make them fire resistant proved quite satisfactory for house-insulating purposes. If the fire-resistant treatment is done by the farmer himself the material cost is only about one-fifth of the first-grade commercial insulation. In the North, also, insulation of walls and ceilings improved comfort conditions, particularly in winter. By proper insulation it was possible to increase temperatures of surfaces such as walls as much as 17° and of air temperatures close to the floor as much as 21° .

The Kansas station has contributed to the low-cost cooling of farm homes in summer by a system which utilizes the lower temperatures of night air. This practice consists essentially of filling the house with cool air during the night and retaining it during the day. The station has devised means and equipment for doing this. Low-cost methods of cooling farm homes with well water and by evaporation have also been developed by the Kansas station. In California increasing interest in summer-comfort cooling has directed more and more attention to the problem of flow of heat through the roofs of farm dwellings. The California station has investigated the heat-retarding properties of various roofing materials and combinations thereof with insulating materials. The tests showed that wood shingles on solid sheathing give the best heat-retarding performance of any of the uninsulated roofs. Galvanized iron on sheathing was considerably cooler than roll roofing or composition shingles. The value of bright aluminum paint as a heat retardant was demonstrated particularly when used on galvanized iron, and when used on wood shingles it was as effective as a $\frac{1}{2}$ -inch sheet of board-form insulation. It was determined that $\frac{1}{2}$ -inch thickness of insulation will stop one-fourth to one-third of the heat which flows through a wood shingle on sheathing, 1 inch will stop one-third to one-half of the heat, 2 inches will stop one-half to two-thirds, and 4 inches will stop from two-thirds to three-fourths.

Rammed-earth construction.—Continued progress has been made in the use of rammed earth as an economical building material for farm structures. In a series of experiments with several soils, rammed earth as prepared by the South Dakota station was shown to be more than twice as strong as puddled soil such as is used in adobe construction, the greater strength being attributed to greater density.

The need for storage of crops to meet adjusted conditions in modern agriculture has made the problem of developing adequate storage methods and equipment a pressing one for the stations, in which, however, they have had wide cooperation from the Department of Agriculture.

Grain storages.—Investigations aimed at the development of adequate grain storages have been broadly cooperative between several of the stations and the Department (B.A.Engin. and B.P.I.). For example, the cost of storing corn was found by the Iowa station to be 3 cents per bushel per year. According to the Georgia station, stalk storage offers no possibilities toward a solution of the storage problems encountered with grain sorghum. Sorghum grain must not contain more than 15 percent of moisture when final storage is undertaken in bins or ricked bags. If heat is to be used in artificial drying of the seed, the intensity must be low and the application extended over comparatively long periods. Rapid drying either by passing heated or unheated air through the grain is injurious to germination. Grain sorghum was stored successfully in three types of bin, two of which resembled the common slatted cornerrib, being 8 by 12 feet at the sill line and 8 feet from floor to plate. The third was of the western box type, 10 by 10 feet at the sill and 10 feet from sill to plate. An A-frame ventilator was used on one of the first two cribs, and the third crib had three-cleated ventilators along the floor with vertical ventilators extending therefrom into the gable.

Vegetable storage.—The study of potato-storage houses in Maine by the Maine station in cooperation with the Department (B.A. Engin.) is typical of the vegetable-storage research at the stations. This work, which is applicable to the colder regions of the United States, has resulted not only in determining the most satisfactory storage conditions for potatoes but durable and efficient structures for this purpose have been developed. It was found that walls and ceilings of storages having high insulation resistance permit the carrying of high relative humidities. This is not possible where wall- and ceiling-insulation resistance is low.

The Tennessee station has successfully adapted the use of an electric heater for curing and storing sweetpotatoes in storages varying in capacity from 500 to 2,000 bushels. A strip heater of 1,000-watt consumption is mounted across the opening in the top of a metal box over each floor ventilator. The false flooring of slats is raised on 2- by 8-inch stringers to a height of 8 inches above the solid floor, and 500-watt heaters are distributed evenly under the false flooring. The power consumption was found to be about 1 kilowatt-hour per bushel.

ELECTRIFICATION

During 1938 there was again a steady increase in the number of farms receiving electric service for the first time. According to the Rural Electrification Administration, for each dollar loaned by the Administration to bring central-station service to farm communities, the farmer spends approximately another dollar for wiring and appliances so as to take advantage of the energy brought to his farm. Some \$3,687,000 worth of residential electrical appliances were pur-

chased by domestic consumers of the power produced by the Tennessee Valley Authority during the 12 months ended June 30, 1939, according to recent reports of the Authority. It is estimated that the use of these appliances increased consumption of electric power by more than 17,600,000 kilowatt-hours. Under the circumstances the stations and the Department (B.A.Engin. and B.H.E.) have made special efforts through their investigations to increase the efficiency with which electricity may be used on the farm and also to increase the number of such uses with the aim of reducing the unit cost of power to the farmer consumer.

Electricity in poultry production.—A study has been completed by the Pennsylvania station of the thermal characteristics of seven electric brooders, representative of practically all known variations in construction, ventilation, and heat distribution, to determine how the heat is distributed and eventually dissipated. It was found that heat distribution under an electric brooder is largely determined and limited by shape, location, and distribution of heating elements; relative position of and application of air movement generated by a fan; kind, size, position, and location of reflectors; and application of heat by radiation or contact. Fan operation in a square brooder with coiled-wire heating element located at the periphery was of little value for heat distribution. In a circular cone brooder with a coiled-wire heating element centrally located in a comparatively small area of the canopy and protected by a perforated metal plate, fan operation served to reduce the otherwise excessive temperature immediately under the heating element. In a circular cone brooder heated by a coiled-resistance wire arranged in a comparatively small circle and placed high so that air currents developed by a centrally suspended fan are forced over it to pass down along the inner aluminum-coated surface of the canopy, the use of a fan was essential and provided the most uniform temperature environment under any of the seven brooders studied.

Auxiliary lighting of laying houses to increase the feeding period as well as the working day for the laying hen has been widely adopted as a practice offering considerable economic advantage. However, doubt as to the advantage of the practice has been raised by the Washington station, among others, in controlled studies of lighting schedules varying from 3 to 24 hours per day. These showed that the least change in production was experienced by birds kept under 24 hours' illumination. The highest over-all production was obtained from birds under 17 hours' continuous illumination per day. Feed consumption showed about the same variations as did production, but there was no relationship between lighting schedule and egg quality. When figured on an annual basis, these experiments indicated that the added cost of feeding, plus the cost of light required to stimulate production, may absorb the additional value of the increased egg production.

Electric insect control.—The research of the Indiana station on the control of the European corn borer by light traps is an example of the continued efforts of the experiment stations to develop efficient means of trapping and destroying insect pests by light attraction and electrocution. The position of the light traps with respect to the

height and vigor of the corn under or surrounding them is of considerable significance, progress results having indicated that traps placed over the tallest corn are the most effective. These studies not only have shown definite promise in the use of light to control the corn borer but have been useful in determining the seasonal character of the insect development in Indiana, such as time of flight and oviposition, the progress of the development of a second brood, and the effect of weather on moth activity.

Practical information on energy requirements and safety features of electric insect traps has been made available by the California station. Experiments conducted with green bottle flies and potato tuber moths showed that there is a definite range of current, depending on the voltage and space between bars of insect traps, that will give a satisfactory kill of insects on an electrocuting grid. Since satisfactory kills were obtained with very small currents and because of the similarity of the current-voltage curves for a 75-percent kill and for breakdown of the gap between bars, the current and voltage necessary to create an arc rather than those necessary to kill the insect appear to be the governing factors.

Electric fences.—Interest in the development of safe and effective electric fences for livestock has resulted in activity by the stations in studying the requirements of such equipment. The New York (Cornell) station has found that electric fences must operate under high voltage to make the required current flow through dry footing. All animals tested indicated that they felt a current of 3 milliamperes. A current of 10 milliamperes was found to stop Jersey heifers, but 15 to 20 milliamperes was required to stop full-grown beef cattle. In order to stop full-grown animals when the footing is dry it is necessary to use a controller capable of delivering 25 milliamperes at 2,750 volts on moist footing. Tests of high-leakage transformers as alternating-current fence controllers showed that optimum performance of such a controller is realized at resonance.

Use of electricity in handling milk.—Electric pasteurization of milk is not only satisfactory from the standpoint of milk quality, according to the California station, but the process is continuous and fast, the control is automatic, and the cost of operation is not greatly different from that of other methods of pasteurization. The Pennsylvania station has shown how electric milk refrigeration may be successfully adapted at the farm. According to the station's findings milk cools more rapidly and uniformly in farm electric coolers when the bath water is agitated, and agitation should continue for at least 1 hour. A pound of ice in melting and warming to 38° F. is as effective in cooling milk as 150 pounds of water increasing in temperature from 37° to 38°. Apparently the best results are obtained with some ice on the coils at the beginning of cooling.

Electric cold storage on the farm.—A large type of refrigerator storage for food on farms has been developed by the Washington station, the cost of which is about \$600. This storage has two compartments operating at temperatures of 35°–40° and 0°–5° F., respectively. The colder compartment is used successfully for storage of frozen beef and other similar materials, whereas the warmer compartment is used to meet current domestic needs for food storage on the farm and for aging meat prior to freezing.

CONSUMER AND FAMILY PROBLEMS

CONTENTS

	Page		Page
Introduction.....	183	Nutrition—Continued.	
Foods.....	184	Mineral requirements and utilization.....	299
Selection for nutritive value.....	184	Dietary habits and indices of nutrition.....	212
Selection for quality.....	195	Textiles and clothing.....	213
Preparation.....	202	The house and its equipment.....	214
Nutrition.....	206	Family economics and home management.....	217
Vitamin functions and requirements.....	206	Family relationships.....	218

INTRODUCTION

Attention has frequently been called in these reports to the fact that the farm is chiefly a producing agency and the home a consuming agency. It would be undesirable and practically impossible completely to separate agricultural experiment station research dealing with production problems from that dealing with consumption problems. In fact, some of the research is of interest and value both to the producer and the consumer. In this section various contributions of the past year in several different fields will be discussed largely from the viewpoint of the consumer but with full understanding that some of the findings may also be of value to the producer.

First in importance, by virtue of the fact that this report is confined to agricultural experiment station research, is the field of foods. Consumer problems include the selection of foods for quality and nutritive value and their preparation for the table in such a manner as best to preserve the qualities for which they are selected and to bring out to the fullest degree their most desirable characteristics. The preservation of home-produced foods in times of abundance for periods of scarcity is a problem with which the farm homemaker has always had to deal. Now the home canning of fruits and vegetables and even meats is giving way to some extent to the preparation of these foods for frozen storage in lockers. Frozen storage of foods has opened up an entirely new series of problems for those who wish to substitute this method for canning or to use frozen foods as available commercially.

An increasing amount of attention is being paid in experiment station research to human-nutrition problems. Studies of food composition show the amount of various constituents present in different foods; research in nutrition shows the need of these constituents and their availability in different foods. The most significant recent development in nutrition research at the experiment stations has been its extension from work with experimental animals to human beings, among whom students at the land-grant institutions predominate. The problem of food selection for optimum nutrition becomes a vital one to many a homemaker throughout the country when her own daughter writes from college that she is serving as a subject in nutrition-research projects.

The homemaker herself may be participating in an experiment station research project dealing indirectly with nutrition by recording what foods her family has been consuming and the quantity of each consumed over a period of time. Dietary studies help to solve

the many problems involved in the best selection of food at the least expense. The analysis of dietary records shows the good and bad points in family or personal food selection. If such dietary studies can be accompanied, as is the case in several projects to be noted later, by studies of the nutritional status of members of the family or of individuals, the picture is completed. Certain deficiencies in the diet are revealed not only in the diet calculations but also in the condition of the people who have been on the diet in question.

Feeding the family in such a way as to promote optimal nutrition is not the only concern of the homemaker. She has more concrete problems in the arrangement of her house, particularly the kitchen, and in the selection of equipment and furnishings. She has her family to clothe, with the problem of deciding what garments to make herself and what to buy ready-made. For both home-made and ready-made garments and household furnishings there is many a problem in selection for satisfaction and durability. The chief burden of textile and clothing selection generally falls on the housewife; equipment-selection and housing-arrangement problems she is quite likely to share with her husband, and when it comes to getting the perspective on all the problems that make up family living the two must work together, and in fact bring into the discussion all of the family members old enough to take any responsibility. Family economics and family relationships are the terms used in research to denote the problems of management of the family's material resources and spiritual resources, respectively, which together make up family living.

Under these general items some of the contributions of the year in experiment station research will be discussed as far as possible from the standpoint of the consumer.

FOODS

A generous supply of home-produced foods continued to be emphasized by agents of the Extension Service and the Farm Security Administration of the Department of Agriculture, as well as by research workers who have studied farm-family diets throughout the country, as the best means of solving the problem of providing adequate diets on very limited cash incomes. Vegetables and fruits are of value chiefly for their minerals and vitamins; milk and eggs for minerals and certain vitamins and also for their high quality protein. Meat formerly was valued chiefly for its high-quality protein, but experiment station research within the last year or two has shown that it also furnishes significant amounts of some of the newer vitamins. Each year new facts on food composition are brought to light which are a help in food selection. Some of the experiment station findings of the past year concerning foods which can be home-produced in certain sections of the country and are available on the market almost everywhere are noted below.

SELECTION FOR NUTRITIVE VALUE

Fruits.—With the importance now attached to providing an abundance of vitamin C in the daily diet, the first thought that comes to mind in fruit selection is its vitamin C content. It is a mistake to think that sole reliance should be placed on citrus fruits or even

tomatoes for this vitamin. Certain other fruits, berries, and vegetables grown in the home orchard and garden may be counted on to furnish a good share of the family's daily requirement of this very essential vitamin. A few fruits are doubly valuable as being also good sources of vitamin A.

The apple has marked varietal and possibly geographical differences in its content of vitamin C. Virginia-grown apples were found by the Virginia station to have such varietal differences in their vitamin C content that the richest variety tested had three times as much of the vitamin per apple as the poorest variety. Black Twig ranked highest, followed in descending order by Winter Banana, Ben Davis, Winesap, York Imperial, Northwestern Greening, Stayman Winesap, Red Rome, Arkansas Black, Rome Beauty, Virginia Beauty, Jonathan, Delicious, Senator Oliver, Grimes Golden, and Lowry. According to the Wisconsin station, Jonathan, Winesap, and Delicious grown in the State are all rather poor sources of vitamin C compared with one of their best varieties, the Northern Spy, 1 pound of which has been calculated to furnish as much vitamin C as 3 to 8 pounds of the other three varieties. The station has a new seedling which is even richer in vitamin C than the Northern Spy. Of several varieties of apples recently tested by the Washington station in continuation of earlier work noted in the 1936 report, Esopus Spitzenburg ranked highest followed by Winter Banana, Stayman Winesap, and White Pearmain, which contained only about a third as much vitamin C as Esopus Spitzenburg.

To get the full vitamin C value of apples the peel should not be discarded, for both the Virginia and the Washington stations have reported that the highest concentration of the vitamin is in the peel, which is from three to five times as rich in C as the flesh. Apparently the vitamin is rather unevenly distributed throughout the flesh. The Washington station reports a lower content in the center of the flesh than near the core or peel and the Maine station more of the vitamin on the sunny side than the shaded side of the whole apple. The temperature and duration of storage are considered important factors in preserving or destroying the vitamin C content of apples. The Virginia station reports a loss of nearly half of the original vitamin C content in apples stored for 6 months at 38° F. This means that by spring apples kept under most conditions of home storage will be only half as good a source of vitamin C as when first harvested. To get the most out of apples as a source of vitamin C, varieties should be selected which have been found to be the richest sources of this vitamin, they should be eaten raw, both peel and flesh, and for winter use should be stored just above freezing temperature. Under such conditions, according to the Virginia station, two or three apples a day would cover the body's requirements. However, no one food need be relied on to furnish the entire requirement of vitamin C for, as will be noted later, there is a wide variety of foods which at one season or another can make a good contribution to the day's needs.

The cantaloup is a seasonal fruit which varies considerably in its vitamin C content. Among six Texas-grown varieties or types Hale Best was found by the Texas station to rank highest in vitamin C with a value of 33.3 mg. per 100 gm. and Rocky Ford lowest with a value

of 26.4 mg. per 100 gm. A wider range in values has been reported in a more extensive study at the University of North Carolina where Rocky Ford grown in the State gave the highest average value, 32.6 mg. per 100 gm., with Hale Best considerably lower, 25.9 mg. per 100 gm. Different specimens of a single variety, Rocky Ford, gave values ranging from 21.6 to 38.2 mg. per 100 gm., showing that factors other than variety are partly responsible for differences in vitamin C content. In general, overripe melons were less rich in the vitamin than the same variety at the best stage for eating. North Carolina investigators estimate that one-half of a cantaloup of average size may supply 40 mg. of vitamin C, an amount which probably represents about the minimum day's requirement or about half a generous allowance of this vitamin.

Among fruits that until recently have received little attention as a source of vitamins is the common currant used so extensively in jelly making. Fresh, ordinary red currants and currant juice are reported by the Massachusetts station to have a high content of vitamin C and also to contain about 180 International Units of carotene (the plant source of vitamin A) per ounce. Persimmons have been found by the Texas station to be unusually rich in vitamin C, with a value of 43 mg. per 100 gm. in comparison with from 29 to 46 mg. per 100 gm. for 6 varieties of oranges, 7 to 37 mg. for 6 varieties of cantaloups, and from about 3 to 9 mg. per 100 gm. for 9 varieties of watermelons as tested by the station. Although watermelons are quite low in vitamin C as compared with many other fruits, the amount in an ordinary serving may easily exceed that of other fruits usually thought of as furnishing considerably more of the vitamin. Among other fruits placed by the Texas station in the same class as the watermelon in contributing less than 10 mg. of vitamin C per 100 gm. are peaches, pears, plums, and pomegranates. None of these, however, would be eaten in as large amounts at a single serving as the watermelon and consequently should be considered much poorer practical sources of the vitamin.

Values reported by the Massachusetts station for the vitamin-A content of a number of frozen fruits show quite strikingly what fruits are good and what poor sources of the vitamin: Dried prune pulp 2,600, yellow peaches 2,000, strawberries 740, red raspberries 520, Youngberries 460, blueberries 110, grated pineapple 55, apples 36, and cranberries 20 International Units of vitamin A per 100 gm. The use of frozen prune pulp or frozen yellow peaches in desserts would make a good contribution to the day's requirement of vitamin A, tentatively estimated to be from 3,000 to 4,000 International Units per day for an adult and from 6,000 to 8,000 for a growing child. Frozen raspberries, one of the most satisfactory of frozen berries for appearance and palatability, are a good source of vitamin C as well as furnishing a fairly large amount of vitamin A. The vitamin C in frozen raspberries, moreover, has been found by the Washington station to be utilized just as well by human subjects as pure vitamin C.

Vegetables.—Certain vegetables have sufficient vitamin C to furnish an appreciable portion of the day's requirements and one or two are among the richest sources of this vitamin. Some yellow vegetables are very good sources of vitamin A. Green leafy vegetables are excellent sources of vitamin A and good sources of calcium and iron.

Seeds and legumes are very good sources of iron and relatively rich in vitamin B₁. Some recent experiment station findings on the vitamin and mineral content of vegetables are noted below.

Asparagus was found by the Massachusetts station to contain 66 International Units of vitamin B₁ per 100 gm. and to retain about 74 percent of the value on quick freezing and 71 percent in canning. (While the vitamin B₁ requirement for man is not yet known with certainty, estimates are placed at from 200 to 400 International Units per man per day.) Frozen asparagus was given a low value for vitamin A, 700 International Units per 100 gm., by the same station. Possibly white rather than green asparagus was used in the tests on which this value was based.

Attention has recently been called by the New Mexico station to the calico bean as a rich source of vitamin B₁ and worthy of more attention. The calico bean, otherwise known as the Manchurian pinto or the Spotted Red Mexican bean, is a red bean with white splotches. It is a little larger, and is said to cook more quickly than the pinto bean. The latter, formerly reported by the New Mexico station to be an excellent source of vitamin B₁, has now been found by the station to be a good source, in the cooked state, of riboflavin and vitamin B₆. The pinto bean like other legumes was also found to be a good source of iron and copper for hemoglobin regeneration. Green lima beans were found by the Massachusetts station to contain practically the same quantity of vitamin B₁, 65 International Units per 100 gm., as asparagus (noted above) but to retain much less, only 46 percent, of the vitamin on freezing and still less, 25 percent, on canning. The frozen beans were, however, a much better source of vitamin A, 1,800 International Units per 100 gm., than the asparagus tested by this station. Frozen wax snap beans were somewhat lower and green snap beans very much higher in vitamin A than frozen lima beans, the values reported being 1,240 International Units per 100 gm. for the wax and 5,400 International Units per 100 gm. for the green snap beans.

A recent bulletin (No. 373) of the Montana station contains information on the content of various vitamins in green snap beans of the Burpee Stringless Green Pod variety when cooked or canned or stored. According to this report an average serving of 70 gm. (a little over 2 ounces) of freshly cooked green snap beans would supply 840 International Units of vitamin A, 23 International Units of vitamin B₁, and from 7 to 12 mg. of vitamin C. A serving of the same beans canned by pressure-cooker methods, stored 6 months, and reheated before serving would furnish 700 International Units of vitamin A, 14 International Units of vitamin B₁, and only 3 mg. of vitamin C. The very low figure for vitamin C in the canned beans was traced to losses during the first 2 months of storage. This was true of both glass- and tin-canned products, but on longer storage the losses continued at a slow rate in the glass but not in the tin. These findings indicate that green snap beans are a valuable vegetable for the home garden in that when freshly cooked they make a very good contribution to the day's requirement of at least three vitamins, and after being canned and stored for several months still contain appreciable quantities of two of these vitamins.

The vitamin C content of snap beans has been found by the New York State station to be affected by a number of factors. Of 13 varieties tested, the vitamin C values ranged from 24 mg. per 100 gm. for Tendergreen to 9 mg. per 100 gm. for Georgian. These differences are probably associated largely with the ratio of seeds to pods, as the seeds are much richer in vitamin C than the pods. The Red Kidney and White Pea varieties, which are ordinarily harvested as seed beans, were among the highest in C content (28 and 22 mg. per 100 cc.) in the green snap bean stage. The vitamin C content of the seeds increased with growth of the pod while that of the pod itself decreased rapidly at first and then remained about constant. Consequently, overmature snap beans tend to be richer in C than beans at the right stage of maturity, particularly in the large-seeded varieties. Storage tests showed that snap beans lose their vitamin C rapidly at all temperatures although somewhat more slowly just above freezing than at room temperature. As an example, Kentucky Wonder lost 7 percent of its vitamin C in 24 hours at a temperature just above freezing and 41 percent during the same period at room temperature. After 2 days the corresponding losses were 19 and 47 percent and after 6 days 53 and 78 percent, respectively. These losses can be prevented in home-grown beans by picking them just before they are to be cooked or canned.

Soybeans vary widely in their vitamin A content and, according to the Alabama station, are a much better source of this vitamin at the stage of eating as green beans than after they have matured. Mature soybeans were also found by the station to lose their vitamin A very rapidly, as much as 50 percent in 2 weeks, on weathering. Consequently, if home-grown soybeans are to be relied on as a practical source of vitamin A in the diet, they should be used while young and green and the surplus canned at this stage, or if the mature beans are preferred, they should be harvested early and not be allowed to stay on the field.

Broccoli, as might be expected from its deep-green color, was found by the Massachusetts station to be quite rich in vitamin A, frozen broccoli furnishing 4,680 International Units of vitamin A per 100 gm., or nearly as much as green snap beans. The station also reported that broccoli loses its vitamin C to an even greater extent than snap beans on standing after harvesting, over 35 percent disappearing during standing for 3 days at room temperature. Commercially frozen broccoli sampled and tested over periods of several months gave a vitamin C content of from 57 to 124 mg. per 100 gm. for the buds and from 110 to 149 mg. for the stem. Corresponding values for fresh broccoli were 67 to 122 mg. per 100 gm. These values show broccoli to be such an excellent source of vitamin C in the fresh and frozen state that, even with the customary losses on cooking, a serving would make a good contribution to the vitamin C content of a meal.

Raw cabbage is an excellent source of vitamin C. In a miscellaneous series of tests the Texas station ranked cabbage, vitamin C value 130 mg. per 100 gm., along with mustard greens 165, peppers 104 to 281, and turnip greens 162 mg. vitamin C per 100 gm. in the group of vegetables of highest vitamin C content. In some localities cabbage is preserved on the farm as sauerkraut for winter use. There has been lack of agreement as to losses of vitamin C in the conversion

of cabbage into sauerkraut and its preservation in this form. According to recent studies at the New York State station, loss of vitamin C in sauerkraut is not associated with the fermentation process but with subsequent losses of carbon dioxide formed during fermentation. This being the case, the less the manipulation, such as would occur during the mixing and preheating necessary in canning sauerkraut in small containers, the greater the likelihood of preserving the vitamin C content. Consequently, the station recommends packing sauerkraut in tanks or barrels rather than canning, and storing at room rather than refrigeration temperature in order to encourage more fermentation with increased production of carbon dioxide. On the other hand, the Wisconsin station suggests canning sauerkraut in half-pint jars. The Massachusetts station has called attention to the value of sauerkraut as a source of vitamin C, stating that tank sauerkraut contains twice as much of the vitamin as tomato or pineapple juice.

Carrots have the reputation of being a rich source of vitamin A, but this depends on the variety and also on freshness. A high value, 3,500 International Units per 100 gm., was reported by the Massachusetts station for frozen carrots (variety not named). The Tennessee station reports a much lower vitamin A value, a little less than 800 International Units per 100 gm., for raw Chantenay carrots at the time of harvesting and 370 Units after 5 months' storage. Chantenay carrots were reported by the New York State and (Cornell) stations to contain from 4.4 to 6.9 mg. of vitamin C per 100 gm. when raw and to retain about 56 percent of the vitamin in the carrots and 33 percent in the cooking water on boiling for 15 minutes. Thinly sliced carrots lost only 14 percent of their vitamin C content on steaming for 20 minutes. Compared with many other foods, carrots are too low in their vitamin C to cause great concern in losses on cooking. The losses in vitamin A on storing are of greater practical importance. It would seem wiser to preserve home-grown carrots in the young tender stage by canning or frozen-locker storage than to harvest them late for winter storage.

Green peas are relatively rich in vitamins A, B, and C and seem to be particularly adapted to preservation by frozen storage. A vitamin A value for frozen peas of 4,800 International Units per 100 gm. was reported by the Massachusetts station. Green peas thus rank between green snap beans and broccoli in vitamin A. In their content of vitamin B₁ green peas were found by the station to be richer than the other three vegetables tested—asparagus, lima beans, and spinach—and also to retain as much or more of the vitamin on freezing and canning. The values reported were 148 International Units per 100 gm. in the raw state with 97 percent retention on freezing and 66 percent on canning. Consistent values for the vitamin C content of fresh and frozen green peas have been reported by the Massachusetts, New York State, and Washington stations. The Massachusetts values were from 25 to 28 mg. per 100 gm. for the fresh unfrozen and 15 to 22 mg. per 100 gm. for the frozen peas. Values of 25 mg. per 100 gm. for the fresh unfrozen and 18 mg. per 100 gm. for the frozen peas were reported by the New York State station, which also noted a loss of about 38 percent during the blanching, chilling, and packaging of the peas preparatory to freezing. Frozen peas cooked directly after removal from frozen storage

retained 59 percent of their vitamin C in the peas and 39 percent in the water, very little actual destruction of the vitamin thus taking place.

The Washington station in cooperation with the Seattle Frozen Pack Laboratory of the Department (B.C. and S.) is carrying on extensive studies of the effect of variety, size, and different processing methods on the content of vitamins A and C in peas grown in the Northwest for the rapidly expanding frozen-food industry. The mean vitamin C content of nine varieties of peas ranged from 11.3 to 29.4 mg. per 100 gm. Frozen peas of the Telephone variety, which had a vitamin C content of 17 mg. per 100 gm. immediately after thawing, showed losses amounting to almost 16 percent after standing for 30 minutes and 27.1 percent after 60 minutes. Storage of the thawed peas in a refrigerator at 4.5° C. did not prevent vitamin C losses, which amounted to about 25 percent in 24 hours. These values point to the wisdom of not allowing frozen peas to thaw before cooking.

Peppers of different varieties appear to be exceptionally rich in vitamin C. Values of 104 to 281 mg. per 100 gm. are reported by the Texas station for peppers of undesignated varieties. The Georgia station has made an extensive study of the vitamin C content of the Perfection pimiento which is widely grown in the State and canned on a large scale commercially. Values of from 167 to 314 mg. per 100 gm. of the fresh pimiento were obtained in the 1937 season and from 128 to 252 mg. per 100 gm. in the 1938 season. Pimientos canned in 1936 had a vitamin C content of 137 mg. per 100 gm. in 1936, 110 mg. in 1937, and 84 mg. per 100 gm. in 1938, thus showing that the canning itself is not so destructive of vitamin C as long periods of storage of the canned product. The pepper as a source of vitamin C affords a good contrast with the watermelon in that the former represents a food high in vitamin C but which is chiefly consumed in small amounts (as in salads) while the latter is a food relatively low in vitamin C but customarily served in large portions. Each may make a decided contribution to the vitamin C content of a single meal.

Potatoes are likewise low in vitamin C, but in low-cost diets may make the only contribution of importance to the diet, depending on the frequency with which they are used and the way in which they are cooked as well as upon other factors not as easily controlled by the housewife, such as variety, maturity, and length of storage.

The effects of a number of these factors have been studied by the Massachusetts station. Varietal differences were less than differences found in a single variety. The average vitamin C value for six samples of Irish Cobblers from different localities was 13.1 mg. per 100 gm., of Katahdins 12.5, of Green Mountains 11.7, and of Rural Russets 11 mg. per 100 gm. The vitamin C content of potatoes of a single crop was found to remain rather constant from the first digging until the potatoes had fully matured, but after digging losses amounting to as much as 50 percent occurred on winter storage, an observation also made by the New York (Cornell) station. All methods of cooking tested by the Massachusetts station resulted in losses, amounting to about 40 percent with either baking or boiling. Boiled potatoes held at 40° F. for 24 hours retained approximately 80 percent of their vitamin C content, and on reheating retained somewhat more of the vitamin if fried than if creamed. Boiling in salted

water preserved the vitamin to a somewhat greater extent than boiling in unsalted water. The importance of potatoes as a source of vitamin C in low-cost diets was emphasized by the Massachusetts investigators through calculations of the relative quantities and cost at prevailing prices of enough oranges, tomatoes, and potatoes to furnish a 50-mg. allowance of vitamin C, this amount representing a conservative estimate of the day's requirement of an adult. These values were given as 4.5 ounces of oranges at a total cost of 3.5 cents, 10 ounces of tomatoes at a cost of 4 cents, and 14 ounces of potatoes (or three potatoes of ordinary size) at a total cost of 1.4 cents. Although these figures should not be accepted too literally because of the many factors affecting the vitamin C content of the foods, particularly the potato, they do show that the ordinary white potato, if cooked properly and served frequently, may at certain seasons supply a large proportion of the vitamin C requirement.

Frozen pumpkins and squash ranked high in vitamin A in the series of studies by the Massachusetts station, already noted, with a value of 18,400 International Units per 100 gm. exceeded only, among the vegetables tested, by spinach, with a value of 30,000 International Units per 100 gm. With this high initial value and the known stability of vitamin A to heat, it may be assumed that a slice of pumpkin or squash pie will make a good contribution towards the day's quota of vitamin A.

The high vitamin A content of frozen spinach has been noted in the preceding paragraph. In vitamin B₁ content the Massachusetts station found spinach to be lower than asparagus, peas, or lima beans (containing only 40 International Units per 100 gm.), but to retain 92 percent of the vitamin on freezing, and 87 percent on canning. For vitamin C, values ranging from 14 to 68 mg. per 100 gm. were earlier reported from Massachusetts with a 47-percent loss on standing for 3 days at room temperature. Samples of frozen spinach gave vitamin C values of 2 to 86 mg. per 100 gm. More recently the station has made a systematic analysis of 10 samples of spinach given various treatments. The raw spinach varied in vitamin C content from 58 to 108 mg. per 100 gm. with the high average of 84 mg. per 100 gm. When cooked in steam this average value dropped to 56, cooked in water 26, frozen 47, frozen cooked in water 28.5, and canned 27.5 mg. per 100 gm. Using the cooking water in all cases would increase the available vitamin C, for a considerable portion is dissolved in the water rather than destroyed. Perfectly fresh spinach, steam cooked in the smallest possible amount of water which is not discarded would seem to be a practical source of vitamin C.

Formerly spinach was highly regarded as a source of calcium but of late it has come into disrepute in this respect, partly as a result of work at the Illinois station. In some experiments in which rats were used as the test animal and the same quantities of calcium were fed as milk and as spinach, it was found that for each 100 mg. of calcium stored in the bodies of the animals on the milk-supplemented diet only 45 mg. was stored on the spinach diet. The calcium in spinach (and also in New Zealand spinach) is in the form of calcium oxalate which the Illinois investigators found to be very poorly utilized. The problem of the utilization of calcium from different vegetable sources has been attacked by the Georgia station by com-

paring the storage of calcium in the bodies of rats receiving skim-milk powder as the sole source of calcium with others on the same diet with half of the calcium of the milk powder substituted by that of dried greens. Turnip greens proved to be nearly as effective as milk, followed in decreasing order by tender greens, collards, and kale, and last by New Zealand spinach which was very poorly utilized.

It is not always safe to make recommendations for human beings on the basis of experimental work with rats. In the case of calcium, the Illinois station has found that human beings are not capable of utilizing calcium as completely as rats. However, the relative effectiveness of different sources of calcium may be the same for rats and human beings. The methods followed in the Georgia study just noted were based on the report of a similar study at the Oregon State College conducted on two human subjects to compare the utilization of calcium from spinach and kale. Here, as in the rat tests, the calcium of kale was utilized to a much greater extent than that of spinach. It is apparent that spinach must give way to some of the other less publicized green leafy vegetables as a source of calcium.

Green leafy and seed vegetables (legumes) are valuable for their iron content although there is now some question as to the relative availability of the iron in different vegetables. In recent work by the Georgia Station vegetables did not fall in exactly the same order for availability of iron when tested chemically and by feeding experiments with rats. By the latter tests black-eyed peas and spinach headed the list of a number of vegetables tested, followed by turnip greens and kale, collards and mustard greens, head lettuce, and finally tender greens and leaf lettuce. These studies were made in the South where turnip greens and collards are the most commonly grown green vegetables but might be used to a much greater extent. As the best means of increasing the low iron content of the diet of many southern families the Mississippi station gives this advice to the housewife—

Serve more green leafy vegetables, raw or cooked (with the pot liquor if cooked) and one leguminous vegetable (black-eyed peas, beans, etc.) every day. A serving of each of these vegetables will furnish most of the iron needed daily by any one member of your family and this will help to prevent anemia and keep them well.

Sweetpotatoes are an important source of vitamin A in the South. This might be easily guessed from the deep-yellow color of the varieties most popular in this section of the country, where the freshly harvested, dry sweetpotato is considered very poor eating in comparison with a moist and sweeter product after curing. Fortunately, curing and storage increase the vitamin A value of the Porto Rico variety. The Tennessee station reports a vitamin A value of less than 5,600 International Units per 100 gm. at harvest, 5,000 after 4 months' storage, and 8,800 International Units after 8 months' storage. Moreover, these already high values were almost doubled on cooking, the corresponding values for the cooked product being 8,500, 12,400, and 14,700 International Units per 100 gm., respectively. Similar tests on the Nancy Hall variety showed no increase in the vitamin A value on storage. The vitamin A value of the raw Nancy Hall was 2,800 International Units per 100 gm. at harvest,

4,000 International Units per 100 gm. after 4 months' storage, and 2,800 International Units after 8 months' storage. These values were more than doubled on cooking, for the corresponding values for the cooked product were 5,900, 9,500, and 6,700 International Units per 100 gm., respectively.

An increase in vitamin A value on storage and cooking is not characteristic of all yellow vegetables, for the Tennessee station reported no change or slight losses, on storage and cooking, in the vitamin A value of carrots, rutabagas, and Amber Globe turnips.

A root vegetable not common in continental United States but very extensively used in Hawaii is the taro, sometimes known as the dasheen. The Hawaii station reports that taro is an excellent source of calcium as determined by experiments not only on rats but also on human beings.

Last on the list of fruits and vegetables selected for discussion because of recent experiment station research in their nutritive value is the tomato. A publication of special interest to both producers and consumers is a bulletin (No. 354) of the Massachusetts station which summarizes in tabular form data from all available published reports on the vitamin C content of raw, canned, fermented, and dried tomatoes, tomato conserves, and canned tomato juice and reports an extension of the varietal studies noted in the 1937 report (pp. 138, 139) to cover three successive crops of the same varieties and strains. The tomato grower, whether on a commercial or home-garden scale, can learn from this publication what varieties and strains of tomatoes have proved consistently high in vitamin C content. The housewife who depends upon her home-grown tomatoes to supply the family's needs the year around may be glad to know that the Massachusetts investigators found no appreciable differences in the vitamin C content of a number of varieties from the hard-green to the hard-ripe stage, and no losses during 10 days of storage at room temperature after picking. If she puts up her own tomato juice, it may be of help to know that the chief losses in vitamin C apparently take place, not during the preliminary heating and pulping, but later when the juice is being concentrated to prevent separating. A thin juice even if it does separate a little is preferable to a thick juice of even consistency. In commercial canning the separation is usually prevented by homogenizing the juice, a process which the Massachusetts investigators found to have little effect on the vitamin C content.

There has been considerable discussion of late as to the use of glass or tin in canning tomato juice. In the Massachusetts station study samples of juice canned in glass and kept either in the dark or light showed small but continuous losses in vitamin C during a 30-day test period while samples canned in tin showed no losses. The Arkansas station also found that tomato juice preserved in glass containers gave from 10 to 15 percent lower values for vitamin C than samples from the same lot processed in tin. In attempting to explain the difference the Arkansas investigators found that tomato juice processed with a little added iron gave values in the chemical test for vitamin C from two to three times as high as the tomato juice alone, showing that the iron was reacting to the test, giving falsely high values for vitamin C content. On the other hand, when solutions of pure vitamin C in a

dilute acid were heated with and without the addition of metallic tin the losses of the vitamin were much less in the presence than in the absence of tin. They concluded, therefore, that there is less destruction of the vitamin in tomato juice canned in tin than in glass but that extraordinarily high values in tin may be looked upon with suspicion as being due partly to iron which may be present and not entirely to the vitamin.

Meats and meat products.—Formerly meats were valued chiefly for their high-quality protein and were thought to be a very poor source of vitamins. Recently they have assumed new importance through the discovery that certain meats and meat products are practical sources of the vitamins of the B group which are so completely removed from one of their best sources—cereals such as wheat and rice—by modern milling processes. The function of these B vitamins as brought out in recent experiment station research will be discussed in a later section, but it may be of interest to note here that the best known of the group, vitamin B₁, is necessary for the complete digestion and utilization of the starch from which it has been removed in the milling of cereals. There is some reason for the popularity of meat sandwiches, for if they are made with white bread the meat makes up in a small way for the vitamin B₁ deficiency in the bread.

Lean pork is exceptionally high in vitamin B₁, according to the Wisconsin station which has made an extensive study of the distribution of the various B vitamins in meat and meat products. Lean pork was found to contain from 130 to 200 International Units of vitamin B₁ per 100 gm., followed by pork and beef heart with values of 80 and 100, leg of lamb 40, beef round 30, and pork and beef kidneys 8 and 5 and livers 5 and 4 International Units per 100 gm., respectively. The losses of vitamin B₁ from different cuts of meat on cooking were found to be much less with frying than roasting, baking, or stewing. In the opinion of the station, meats, even though used in the diet to the extent of only 7 percent—

are capable of supplying one-third of the human vitamin B₁ needs. When meat such as pork is used, the proportion of the day's requirement thus supplied is correspondingly increased. A pork chop even when fried may supply the total daily requirement of this vitamin.

As for the other vitamins of the B group, the Wisconsin station investigators report that one-tenth of a pound of fresh liver or 1 pound of fresh beef round will furnish the suggested daily requirement of riboflavin, and a quarter of a pound of veal or lean pork the requirement of nicotinic acid, the substance now known to be specific for the prevention and cure of the most characteristic symptoms of pellagra. The superiority of pork over other meats as a source of vitamin B₁, as well as its relatively high content of nicotinic acid, is of significance on the farm, where pork is more often home-produced than are other meats. The higher values of liver than lean meat in riboflavin and nicotinic acid show the importance of using storage and glandular organs as well as muscle meat.

Cereals and cereal products.—The superiority of unmilled as compared with refined cereals in the B vitamins has been referred to above. Unpolished rice has been shown by the Arkansas station to be superior also to polished rice in its proteins as determined by rat-

feeding experiments. The simple change from polished rice to whole or brown rice will do much to improve the diet in the B vitamins and in the quality of the proteins.

Another improvement in the diet which is very easy to bring about if the bread supply is made at home is to include dried milk in the recipe. When bread containing no milk was compared at the Illinois station with bread containing 6 and 12 percent of milk solids by feeding the three types to well-matched young rats, the animals receiving either of the milk breads gained more in length and weight than those receiving the bread made without milk. Their bodies at the end of the experiment also contained more calcium, with those on the 12-percent milk-solids bread definitely superior to those receiving half as much of the milk solids. If commercially made bread is used, it is a good plan to select milk bread, particularly if there are children in the family, for the added nutritive value is worth the small additional cost.

SELECTION FOR QUALITY

The appearance and palatability of foods count for more than their nutritive value in their popularity in the diet. The cooking or culinary quality of certain foods has long been a matter of concern to the housewife who prepares them for the table, and to the producer whose profits depend so much on the quality of the product.

The apple varies as widely in appearance, palatability, and culinary qualities as in vitamin C content, and consequently has received much attention from this standpoint at experiment stations in apple-producing States. The New York (Cornell) station has recently published (Memoir 225) the results of an investigation covering a period of 5 years during which 13 important varieties of New York State apples were tested periodically, and 15 other varieties occasionally, for their cooking properties as well as their flavor and texture both raw and cooked. After many trials the cooking methods finally selected as most satisfactory for retention of flavor were as follows: For applesauce, a hot sirup made from one-third cup of sugar and three-fourths cup of water was added to $1\frac{1}{2}$ pounds of peeled and cored apples which were then cooked in a covered pan as rapidly as possible until tender. For baking, cored, unpeeled apples in the proportion of 1 pound of apples to 5 level teaspoonfuls of sugar were placed in a baking dish, covered, cooked in the oven at a temperature of 400° F. until nearly tender, and then removed from the oven and the cooking completed by means of the heat retained in the covered dish.

For eating raw, McIntosh was rated as best of the varieties tested. For baking, Rome, Cortland, and Northern Spy proved most satisfactory; for sauce, Cortland, Northern Spy, and Rhode Island Greening; and for pies, Rhode Island Greening, Northern Spy, Cortland, Jonathan, and Twenty Ounce. For use raw in salads, Cortland outranked all others because, in addition to other good qualities, it does not turn brown after it is cut.

Glazing, or surface cooking in a concentrated sugar sirup, is considered by the Massachusetts station to give a more attractive and palatable "baked apple" than baking in the oven in the conventional way. Although the method was used on a large scale in the selection

of apple varieties most suitable for commercial canning as whole baked apples, it appears to be equally practicable for small-scale use in the home. The glazing method as used in this study consists simply in cooking the cored but unpeeled apples in a 40-percent sugar sirup until tender, the time required varying from 5 to 10 minutes, depending on the variety, maturity, and size of the apple and the time it has been held in storage. Of the varieties tested, those relatively high in pectin and acid proved most satisfactory. These included Baldwin, York, Northern Spy, Rhode Island Greening, and Gravenstein, with preference for the first three because of their better color.

Another reason for recommending glazing in preference to baking is that the method was found to be less destructive of vitamin C, the losses averaging 44 percent in the glazed and 65 percent in the baked apples. The different varieties were not alike in the distribution of the vitamin between solid and liquid in the glazed apples. With Northern Spy and Rhode Island Greening equal amounts of vitamin C were found in the solid fruit and the sirup, while with Baldwin and York Imperial there was less, and with Delicious more of the vitamin in the fruit than the sirup. This difference is, of course, of no practical value provided the sirup or juice is not discarded. A good rule to follow with most cooked foods is to use the cooking liquid.

The vegetable most extensively studied for cooking quality at the experiment stations is the potato. It would be a boon to producers and consumers alike if simple reliable tests could be devised for checking the cooking quality of potatoes, particularly for mealiness and tendency to slough—one a desirable and the other an undesirable quality. The development of such tests and an understanding of what is responsible for desirable and undesirable qualities in potatoes are the objectives of several experiment station projects.

One of the most satisfactory tests for cooking quality in potatoes thus far proposed is the specific gravity test, which is being quite generally used. This test, as described by the New Hampshire station, consists in dropping uncooked potatoes in a series of salt solutions of different densities until a solution is found in which the potato just barely floats, which means that the density or specific gravity of the potato is the same as the known density of the solution. The New Hampshire investigators feel that the test to be reliable must be carried out on at least 50, and preferably 100, potatoes of a single lot. In the majority of samples tested, potatoes ranking from mealy to very mealy in cooking and judging tests had specific gravities in the uncooked samples of 1.08 to 1.1, while no sample classed as soggy or waxy had a higher specific gravity than 1.07. Potatoes judged excellent in general cooking quality were all in the groups having specific gravities of 1.09, 1.1, and 1.105. An average specific gravity of 1.093 was given a quality rating of 93. As thus tested 7 varieties of potatoes grown in two localities of the State had quality ratings as follows: Green Mountain 94 and 82, Smooth Rural 89 and 75, Russet Rural 84 and 81, Irish Cobbler 83 and 73, Warba 81 and 71, Chippewa 79 and 65, and White Rose 71 and 60, respectively. These values might be interpreted as showing that one of the two localities produced better potatoes than the other, and that only the Green Mountain grown in the better locality had really excellent cooking qualities. If the specific gravity test should continue to be satisfactory, specifications might be

set up in terms of quality ratings or, preferably, specific gravity, provided there were sufficient consumer demand. However, specific gravity probably does not tell the whole story.

The tendency of potatoes to slough badly on cooking is an unsatisfactory quality for which tests and also methods of checking are desirable, for sloughing results in considerable losses as well as a poor appearance in the cooked potato. The Colorado station attributes sloughing to the dissolving of the cell-cementing material, presumably pectin, in the cooking water. If there is sufficient calcium in the cooking water or in the potato itself, the cell-cementing material does not dissolve in excess and sloughing does not occur. Using potato varieties with high sloughing tendency (Irish Cobbler, Brown Beauty, and Russet Burbank), the Colorado investigators controlled sloughing simply by adding a small amount of a calcium salt to the water in which the potatoes were being cooked. Cracking and fracturing could be controlled only with much higher concentrations of calcium than necessary to eliminate sloughing. Calcium chloride in a concentration of 0.1 percent controlled sloughing and in concentrations up to 0.25 percent did not affect the mashing quality of the cooked potato. A concentration of 0.5 percent was required for good control of fracturing, but the potatoes became rather too firm to give the best quality on mashing. Another calcium salt, calcium sulfamate, gave equally good results and is recommended in preference to calcium chloride as it does not take up moisture from the air as does calcium chloride. A suggestion that may prove practical to prevent sloughing losses in the cooking of large quantities of potatoes as in institutions is to mix calcium sulfamate with ordinary table salt in the proportion of 1 part of the calcium salt to 8 parts of the table salt and add to the cooking water in amounts to season the potatoes.

The belief that the intercellular cementing material in potato tissue is pectic in nature has also been advanced by the New York (Cornell) station as the result of attempts along various lines to develop satisfactory objective tests for potato mealiness. Tests of the tensile strength (or resistance to breaking apart) of slices of potato tissue after cooking at different temperatures showed that the weakening of the cementing material takes place to a certain extent at any temperature between 45° and 75° C. (113° and 167° F.) with complete weakening at the higher temperature. As starch does not gelatinize at as low a temperature as 75° it was concluded that separation of the cementing material does not depend upon gelatinization of the starch. No difference was noted between soggy and mealy potatoes in the adhesion of the cells of the raw or cooked tissues. In line with this is the report from the Massachusetts station that extensive analyses for pectin of over 20 samples of mealy and soggy potatoes showed no relation between mealiness and pectin content. No differences were noted in the effect of heat on the permeability of the tissues of soggy and mealy potatoes as determined by measuring the resistance to the passage of an electric current through potato sections.

The next attempt of the Cornell investigators to determine what actually happens in the cooking of potatoes was to see if a softening of the tissues similar to that obtained in cooking could be brought about by chemical means and it was in this study that definite proof

was obtained that the intercellular cementing material in potatoes is pectic in nature and that doneness in cooking potatoes occurs when this material has been weakened to the point of separation of the tissue cells. Solution of salts capable of removing calcium from its combination with pectin softened the tissues, while solutions of other salts having no effect on calcium in combination with pectin did not. Moreover, the softened tissues were hardened by treatment with calcium chloride. These findings led the Cornell investigators to conclude that changes in the nature and amount of pectic substances in the potato during maturing and storage play an important part in the cooking qualities of potatoes and that the cation (mineral) content of the potato itself and of the water in which it is cooked is also of importance.

Meat.—Beef roasts and steaks are usually selected for quality on the basis of the United States grades of Choice, Good, Medium, and Common. To determine the extent of differences in quality of these grades in steaks as well as to extend the study of broiling methods noted in the 1938 report, home economists of the Missouri station broiled pairs of 1-inch porterhouse steaks of U. S. Choice, U. S. Medium, and U. S. Common grades at constant temperatures of 175° and 200° C. (347° and 392° F.) to an internal temperature of 58° C. and also pairs of 1-inch thick steaks of U. S. Choice, Good, and Medium grades and 1½-inch thick steaks of U. S. Common grade at temperatures of 200° to 250° to the same internal temperature. In all cases the steaks were turned when the internal temperature reached 44°. Highly significant differences in palatability of the different grades of steaks were found except for the U. S. Choice and U. S. Good which were equally palatable. The broiling temperature of 175° proved too low to brown the steaks sufficiently, and of 250° too high, in that the steaks cooked unevenly, were somewhat burned, and had greater cooking losses. The steaks broiled at 200° were attractive in appearance and scored high in palatability.

Not only grade but cut and class of beef have an effect on palatability. This has been shown by the Minnesota station in comparisons of the juiciness, tenderness, cooking losses, and palatability of roasts from three cuts—eleventh-twelfth rib, bread-and-butter cut, and round—of six steers graded High, Medium to Good, and seven cows graded Good. All of the cuts were roasted at a constant temperature of 150° C. to an internal temperature of 58°. As was to be expected, the round of beef ranked lower in tenderness and palatability and higher in cooking losses than the other two cuts. In juiciness there was no marked difference for all three cuts and in tenderness for the rib and the bread-and-butter cut. The rib roast showed the lowest cooking losses of the three. No differences could be detected between corresponding cuts from Medium and Good grade heifers except that the rib roast of Medium grade contained more moisture and less fat than that from the Good grade. In practically all respects, but particularly in flavor and aroma, the cuts from steers ranked higher than those from cows—a point to remember in selecting beef for highest quality.

Frozen storage.—The newest and, in some localities, the most popular method of preserving home-produced meats, fruits, and vegetables is by freezing and storing in freezer lockers. The rapid increase in

the practice of this method of preservation has tended to outstrip research on the many problems involved. However, a number of the stations are now devoting much attention to research in this field. In tests conducted by the Iowa station on retail cuts of beef and pork frozen at or near 0° F. for 8 hours and stored at temperatures below 15° it was found that the length of time which beef would retain acceptable palatability depended on the grade of meat and the amount of surface exposed to drying. The higher grades kept more satisfactorily in freezer storage with less shrinkage and a higher palatability score than the lower grades. The lower shrinkage of the higher grades was attributed to the additional fat covering the lean. Similar protection of the lean in pork cuts was afforded by the fat, but the fat in pork cuts tended to become rancid in a fairly short time. Tests by the Minnesota station showed a significant undesirable change in the flavor of the fat of pork-loin roasts in as short a time as 4 weeks. Consequently surface fat should be removed as much as possible in preparing pork roasts for the freezer locker but retained on the beef roasts. Wrapping the roasts in two layers of paper is recommended by the Iowa station as a help in prolonging the time of satisfactory storage.

In freezing poultry the question arises as to whether it is better to chill the birds overnight before freezing or to freeze them within an hour or two after killing. A comparison at Iowa State College of the two methods showed that with White Plymouth Rocks the birds chilled overnight before freezing were more tender than those frozen within 2 hours after killing but with Buff Orpingtons no differences in tenderness with the two treatments could be detected. Juiciness and general palatability except for tenderness were the same with both treatments.

For the farm family planning to make use of freezer-locker space to preserve some or all of the home-grown fruits and vegetables formerly canned for the winter supply two problems are uppermost. The farmer needs to know which of the types and varieties he can grow are best adapted to freezing. The housewife needs to know the best methods of preparing these home-grown foods for freezer-locker storage. Information on both points is already available from a number of sources and studies are in progress at several of the stations to meet the many requests for information on fruits and vegetables especially adapted to local conditions.

A publication of the Tennessee station (Bul. 168) contains information, secured during an extensive survey of the frozen fruit and vegetable industry and freezer-locker installations throughout the country, on proper temperatures for freezing and storage, the selection of containers, general methods for preparing the materials to be frozen with special directions for fruits and vegetables, and the cooking and serving of frozen foods in the home.

A mimeographed Department circular (B.C. and S.), representing the joint contributions of the Seattle Frozen Pack Laboratory of the Department and the Oregon station, contains useful information of a general nature on the preservation of fruits and vegetables for freezing with lists of the varieties and types common in the Pacific Northwest which are best adapted to freezing. The desirable varietal qualities of the fruits and vegetables included in the list are described

with directions for harvesting, handling, and preparing the material for freezing and suggestions for the most suitable types of containers and methods of packing.

The North Dakota station has summarized available information from various sources on types and varieties of fruits and vegetables suitable for small-scale freezing and is now studying varieties particularly adapted to conditions in the State. The Mississippi station has published a list of varieties of Mississippi-grown snap beans, lima beans, and beans best suited for freezing with specific directions for their treatment.

With all the emphasis that is being given to varietal differences there may be a tendency to forget that certain factors which affect quality in cooked or canned fruits and vegetables, such as freshness and the proper stage of maturity, are equally important for freezer storage. The cooking properties of frozen vegetables as well as their appearance after freezing must also be considered. Extensive studies have been conducted by the Washington station, working closely with the Seattle Frozen Pack Laboratory, on the cooking quality of green peas preserved on a commercial scale by the frozen-pack process. When the shortest possible cooking periods were used, steaming and waterless cooking preserved the natural flavor of the peas better than boiling in water, but with slight overcooking a strong flavor developed, especially with the waterless cooking method. Peas cooked in water collapsed less than those cooked without water. Differences in the maturity of the peas when picked produced greater changes in the texture of the cooked peas than did differences in variety.

Freezing, even more than canning, accentuates the poor as well as the good qualities of the original food. When foods are prepared in the home for freezing the housewife can safeguard the quality of the product by care in the selection and preparation of material. In using commercially produced frozen foods she has only the appearance, flavor, and (for vegetables) the cooking quality of the product as a guide. However, according to the New York State station, it is possible in the laboratory to judge the quality of most frozen vegetables by certain tests. One of these is the bacterial count. A count under 80,000 per gram of the material is considered by the station to show that the product had been blanched at a high enough temperature to kill practically all of the bacteria on the surface of the fresh vegetable, and that all of the processes followed during freezing, storage, transportation, and marketing had been carried on under such conditions as would prevent contamination of the product or multiplication of bacteria that might have been present. Careless handling at any time from preparation through marketing would give a final bacterial content of at least 100,000 or possibly as much as 200,000 or more per gram.

The second test proposed is a chemical test for the enzymes known as catalase and peroxidase which are normally destroyed in the blanching process as a means of preventing the development of off-flavors and loss of color. If neither the catalase or peroxidase activity of the frozen vegetables exceeds 1 percent of the normal activity of the unblanched vegetable, it is a sign that the blanching has been insufficient and the product will have a poor flavor and color if it is not kept at a very low temperature. The third test is the determination of

the vitamin C content of the frozen food. A normal or high vitamin C content is considered good evidence that the vegetable was not overmature when harvested and was properly handled during the necessary processing before freezing, and that the frozen product was stored at a sufficiently low temperature. This test does not imply that there are no losses in vitamin C during the freezing of vegetables but that these losses should not exceed definite limits. Values considered by the station as normal for certain carefully handled frozen vegetables are peas 17 mg. per 100 gm., lima beans 18, spinach 50, sweet corn 8, and snap beans 14 mg. per 100 gm.

Consumer demand for standards for frozen vegetables might make possible the adoption of specifications based upon these or similar tests. In the meantime the few figures just given, although not absolute, are useful in showing the relative richness in vitamin C of different frozen vegetables, supplementing the data given in an earlier section.

Canning.—Frozen storage of foods has by no means supplanted canning either as a commercial or home industry. The inevitable competition between the two methods involves many factors of which cost at present favors canning. The greater resemblance of frozen than canned food to the original material in appearance and flavor is resulting in a reexamination of canning methods for possible improvement. Suggestions along two lines have been made by the New York State station with commercial canning in mind but with possible application to home canning. One of these suggestions is that in canning tomatoes of high acidity, and highly acid fruits such as cherries, plums, peaches, and apples, lower temperatures may be followed than heretofore recommended. In suggesting this possibility the station points out that the canning industry is primarily based on the efficiency of the heat treatment to prevent spoilage, and in the interest of safety in this respect unnecessarily high temperatures may have been adopted for certain foods. Studies already made by the station on acid fruit juices, such as apple, grape, and rhubarb, indicate that this is the case, but more information is thought to be needed on the time and temperature of processing for various fruits and vegetables.

The other suggestion of the New York State station concerns a constituent of fruit and vegetables that has already been discussed in connection with the cooking quality of potatoes, namely, pectin. The addition of small amounts of suitable calcium salts to certain fruits and vegetables before canning is suggested as a means of making the tissues firmer and more like the raw material by uniting with the pectin and thus holding the tissues together. For some products this would be a disadvantage which is illustrated by the well-known unsatisfactory hardening of peas and corn cooked in hard water. On the other hand, with a vegetable such as tomatoes or a soft fruit such as peaches, it would be a decided advantage to have the canned product resemble the raw in firmness. This has been accomplished at the New York State station by the simple addition of as little as 0.05 to 0.1 percent of calcium chloride to tomatoes before canning and at the Colorado station with peaches in a similar manner. Preliminary tests at the New York State station have also shown like procedures to be useful in the freezing of fruits. If the calcium salt is added to the fruit long enough before freezing for the calcium to diffuse through the entire tissue, the natural structure of the fruit

is preserved and with such fruits as apples and peaches browning on defrosting is prevented. The use of calcium is also suggested in jelly making for fruits that contain pectic acid but insufficient pectin.

While chemists are introducing new canning methods, physicists and bacteriologists are continuing to help in the control of standard methods. The attention called by the Nebraska station to frequent inaccuracies in the pressure gages of steam pressure cookers, as noted in the 1938 report (pp. 154 and 155), has resulted in the checking and correcting of many gages throughout the country with presumably a lessening of spoilage of nonacid foods canned by pressure-cooking methods. An examination by the Arkansas station of a number of samples of spoiled home-canned products showed that inaccurate pressure-gage readings had been the cause of spoilage in several instances. Seven of twelve gages checked by the station were found to be very inaccurate and to have been responsible for under-processing. Other samples were spoiled from leakage due to the use of worn or cracked rubber rings or bent covers and from food particles between the jar lip and ring. From a can of flat-sour peas a heat-resistant organism was isolated that had caused spoilage on storage at a rather high temperature. Another cause of spoilage was the use of too large containers for products with low heat penetration. In this instance spinach had been canned in gallon jars. It is recommended that for such foods no larger containers should be used than No. 2 tins or pint glass jars.

Meat-canning methods are being reinvestigated for a possible revision of techniques, particularly time and temperature of sterilization. Bacteriologists of the North Dakota station are checking the rate of heat penetration in meat canned in glass by the pressure-cooker method. Tiny glass ampoules of heat-resistant bacterial spores were imbedded in the center of the meat-packed jars. During the processing at 15 pounds' pressure, which was continued for various periods of time, the rate of heat penetration was comparatively slow. An average of 30 minutes was required to reach 100° C. Although complete sterilization was never obtained, bacteriological examination of the jars immediately after processing showed that the organisms, which included the one causing botulism, had been killed in most cases. The possibility that slow-developing spores might still be present could not be tested until after the cans had been held in storage for some time. In similar studies at the Texas station, ground beef was inoculated directly with spores of a strain of the botulism organism and processed at 15 pounds' pressure for 1 hour in tin cans of two sizes. In tests made after 4 weeks there was no evidence of toxins or live organisms, but since the exact heat resistance of the spores used in the inoculation had not been tested definite conclusions are awaiting further work.

PREPARATION

Food preparation, through research, is changing from an art to a science. New discoveries and inventions necessitate new methods, revolutionizing old processes. Adjustments in recipes formerly made by rule of thumb are now yielding to mathematical formulas. Among the food-preparation problems receiving attention at the experiment stations during the year were altitude cookery, the use

of lard and its hydrogenated compounds as shortening agents and in frying, and the use of various stabilizers and emulsifiers in foods.

Cake making at high altitudes.—The altitude laboratory of the Colorado station, mentioned in earlier reports, has made possible controlled studies of cake making at different altitudes with the establishment of correct formulas and recipes for any altitude. Practical application of this work has been made in the dining cars of one of the transcontinental railroads in whose high-speed trains adjustments for different altitudes have to be made from one meal to another. The earlier work of the Colorado station on angel food cake has been extended to the more complex formulas for whole-egg sponge cake and whole-egg butter-type cakes with the general conclusion that, contrary to popular opinion, cakes baked at high altitudes need not be inferior, but may be superior to cakes baked at low altitudes.

As is well known, water boils at a lower temperature at high altitudes than at low. In cake baking the temperature within the batter is never higher than the boiling point of water unless the cake is overbaked and begins to burn. The higher the elevation the lower is the final temperature within the cake and the longer is the time required to reach it. The slower process makes the cakes more tender, in fact so tender that alterations have to be made in the recipes.

In the earlier work at the Colorado altitude laboratory on angel food cake the adjustment in ingredients considered most satisfactory with increasing altitude consisted in decreasing the amount of sugar until at very high altitudes the adjusted recipe contained almost no sugar. In the more recent work on whole-egg sponge cake and butter-type cakes it has been found possible to keep the sugar constant by increasing the proportion of liquid (egg and milk) to sugar. At sea level the amount of egg that can be used even in butter-type cakes without making the cake tough is rather small, but as the altitude increases the greater tenderness of the cooked egg permits the addition of more eggs without the danger of toughness. As a result the cake, with its higher egg and milk content, has an increased nutritive value and retains the sweetness characteristic of cake. With the extra liquid there is also less tendency for high-altitude than low-altitude cakes to dry out on standing.

The effect of egg quality on the properties of various cakes has also been studied in the Colorado altitude laboratory with the finding that the weight of the firm egg white is an excellent index of the behavior of eggs in cake batters, for the greater the weight the larger is the volume of the butter-type cake. Eggs of poor quality, in which the white is not firm, and dried eggs give a more crumbly product of smaller volume than eggs with firm whites. By slightly increasing the egg content of the batter and at the same time maintaining the liquid content constant, both volume and tendency to crumble are corrected. The ratio of yolk to white also has an effect on the properties of cakes. When the liquid content of the cake batter was kept constant and the proportions by weight of egg yolk and egg white were varied it was found that a decrease in the yolk tended to decrease the volume of the cake more than a decrease in the white.

With quality depending so much upon the proportion of ingredients, particularly the liquid to sugar ratio, it is readily seen that unless great care is taken failures will result from changes in these propor-

tions. With eggs varying in size and even in yolk to white ratios, with shortening and flour (even when sifted) varying in the weight of like volumes, and with measuring devices not divided into sufficient fractional parts for the slight alterations necessary, it is difficult to get the right proportions by volume measurement and number of eggs, and weighing the ingredients becomes almost necessary. The Colorado investigators say that—

Until the housewife is willing to adapt herself to measurement by weight, it will remain difficult to obtain results that approach uniformity at high altitudes. With weight measurements cakes superior to those produced at low altitude are easily obtained.

However, for those who do not have balances, or prefer to continue with the older method, the Colorado station investigators have worked out formulas of the ordinary type that will give fairly satisfactory results.

The effects of the quality and nature of the ingredients of cake mixtures are problems entering into successful cake making at any altitude. Probably many a failure with a tried and true recipe is due to the difference, noted above, in egg size and ratio of yolk to white. The type of shortening agent is another factor requiring some adjustments either in proportions of ingredients or in method of mixing.

The use of lard as a shortening agent for cake as well as for pastry is being encouraged in sections of the country where lard is more available than other shortening agents. Successful cake making with lard involves chiefly changes in technique in mixing the ingredients. In studies at the Nebraska station three methods of mixing were developed for making cakes by the butter-cake formula but replacing the butter with 70 percent by weight of lard, increasing the sugar content 10 percent and the liquid 15 percent, and substituting 22.4 percent of cornstarch for general-purpose flour. The hot-lard method, which is a variation of the muffin method of mixing, proved satisfactory for cakes with soft or melted lards kept without refrigeration. The single-stage method, by which all ingredients are mixed together at one time, was also satisfactory for soft lards. The cornstarch method, which is a modification of the sponge-batter method, was judged more desirable for use with firm than with soft lards. The flavor of rancid lard produced by poor storage conditions was masked by both the hot-lard and cornstarch methods of mixing.

In a comparison by the Iowa station of the value for plain cakes of a number of shortening agents the method of combining the ingredients was found to be one of the most important factors in producing cakes of desirable quality and palatability, particularly when lard was the shortening agent. Methods in which the egg is added to the milk or added last, either with or without a portion of sugar, to the batter, very greatly improved the quality and palatability of cakes made with oils, and to almost as great an extent those made with lards. Even cake made with butter usually ranked higher when the egg was added last than when added to the creamed mixture. Of all the methods tried, the conventional sponge in which one-half of the sugar is beaten into the eggs to form a light fluffy sponge and folded into the cake batter last gave the best results.

Doughnuts.—This type of dough mixture cooked by deep frying was studied by the Wyoming station for the possible effects of high

altitude (the station being at an elevation of 7,200 feet) and of different types of fat. A complicating factor was the lack of standard sea-level recipes for doughnuts, as will be seen from the reported analyses of 25 low-altitude household formulas. On the basis of 100 parts of flour the ranges in proportions of the other ingredients were sugar 17 to 59 parts, whole eggs 10 to 28, milk 36 to 55, fat 2 to 12, and baking powder 2 to 7 parts. Doughnuts made at the station from one of the sea-level recipes were very poor, showing a tendency to crack with high absorption of fat. Fairly satisfactory results were obtained using half hard-wheat and half soft-wheat flour and for every 100 parts of the flour 40 to 43 of sugar, 16 to 20 of whole eggs, 43 to 53 of milk, 2 of fat, and 1 to 1.8 parts of baking powder. It is difficult to compare these proportions with low-altitude recipes because of the wide variation in the latter. The quantities of sugar, milk, and eggs are between the minimum and maximum quantities found in the low-altitude recipes, fat the same as the minimum, and baking powder less than both and very much less than the maximum. The increase in liquid (milk and eggs) is in line with the Colorado cake work. The proportion of yolk to white was also found to be of some importance. Whole eggs tended to make the doughnuts tough, while with too high a proportion of yolk to white the doughnuts became too short and cracked open. Good results were obtained with eggs in the proportion of one-third yolks to two-thirds whole eggs.

The smoking points of the various fats used by the Wyoming station were approximately the same as reported for low altitudes, but the temperatures frequently recommended at low altitudes (350° to 400° F.) proved too high. Doughnuts fried at 350° for 3 minutes were golden brown in color, at 365° for 2 minutes a deep brown, and at 390° for 1½ minutes a very dark brown. Under the same conditions of frying approximately the same amount of fat was absorbed for each of the different fats used—lard, corn oil, cottonseed oil, and a hydrogenated fat. Two percent more fat was absorbed at the highest than at the lowest temperature used, probably because of the broken surface at the high temperature resulting from too rapid an expansion. With repeated use the smoking points of the different fats were lowered considerably, but less with lard than with the others. These changes were accompanied by increases in acidity. After 12 hours' use in frying the acidity increases were not enough to cause disagreeable flavors in the doughnuts but after 18 hours the flavor of the doughnuts fried in lard and hydrogenated vegetable fats became slightly objectionable. Storing lard in a cool place and keeping it tightly covered are recommended as means of prolonging its frying life through preventing the development of rancidity.

In deep-fat frying studies at the Indiana station very little difference was found in the absorption of fat from various sources with one exception. Hydrogenated soybean lard (from hogs fed soybeans) was absorbed to a much less extent than nonhydrogenated soybean lard, commercial lard, hydrogenated lard, and hydrogenated vegetable fats.

Refrigerator ice creams.—A problem recently attacked in the food-preparation laboratories of the University of California was the production of refrigerator ice cream (frozen without stirring) having both a smooth body texture and a low fat content. The use

of whipped cream to incorporate sufficient air in the mixture and but-terfat to prevent crystal growth and also the separation of the cream largely results in a product of high fat content. The plan followed in the study was to test various so-called stabilizers in a modification of the standard basic recipe containing, as far as possible, similar proportions of fat, milk solids, and sugars as commercial ice creams. Again pectin comes into the picture as a very useful food ingredient, for it proved one of the most satisfactory stabilizers, although giving the product a rather characteristic flavor. The best stabilizer of all was agar used in 0.2-percent concentration with from 12 to 15 percent of dried skim milk. Agar also proved the best stabilizer for refrigerator sherbets and agar or gelatin combined with mayonnaise for frozen fruit salads. Recipes for household use have been developed, including a vanilla ice cream with agar, pectin, or cornstarch; a maple ice cream with apple pectin; and a chocolate ice cream with citrus pectin.

NUTRITION

VITAMIN FUNCTIONS AND REQUIREMENTS

Food requirements are determined and expressed in terms not of actual foods such as meats, vegetables, fruits, etc., but of their essential constituents such as fats, carbohydrates, proteins, minerals, and vitamins. In recent years interest has centered largely in the last two of these constituents, particularly in vitamins, for it is still a scant 30 years since the existence of such a group was suspected. From the first, experiment stations have played an important part in the discovery and study of the vitamins. A comparatively new field of experiment station research has been the development and use of methods to determine the nutritional status of human beings with respect to vitamins and some of the other important food constituents.

Vitamin A.—Night-blindness tests, or (to use a more scientific term) dark-adaptation tests, as a measure of vitamin A nutrition continue to receive attention in a number of experiment stations. Although it is an accepted fact that night blindness, if eye defects are ruled out, is due to lack of vitamin A or carotene (the plant source of the vitamin), the expense and size of the most approved instrument for making the test, the Hecht adaptometer, has led to improvements in the technique for conducting and evaluating the test with the biophotometer (Pennsylvania station) or other instruments of similar principle on the market (Massachusetts station). A new instrument of simple construction has been developed at the Rhode Island station and given the name rhodometer, from rhodopsin, the scientific name for the vitamin A-containing pigment in the eye, otherwise known as visual purple.

An entirely new method of diagnosing vitamin A deficiency is being tested by the Florida station, namely, the differential leucocyte, or white cell, count of the blood. Working first with rats, the Florida investigators noted during vitamin A depletion and recovery characteristic changes in the number and size of the white blood cells as observed in blood smears under the microscope. Applying similar tests to human blood they found that subjects with obvious symptoms of vitamin A deficiency showed similar changes in their white blood cells to those of the vitamin A-deficient rats and in general responded

in a similar manner to large doses of vitamin A. Should this test prove to be specific, its simplicity will make it of great value, but further work in many laboratories is necessary to confirm the results and show the applicability of the test under all conditions. A comparison of the blood test with the biophotometer readings has already been made by the Florida and Georgia station investigators working together on a group of children in Georgia, with results indicating a fairly good agreement but with greater sensitivity of the blood test.

The B vitamins.—First and in some ways the most important of these vitamins is vitamin B₁, now known as thiamin. It is largely through research at several of the experiment stations that it has been definitely shown that this vitamin is required for the complete metabolism of carbohydrates and consequently that the requirement for vitamin B₁ is in direct proportion to the amount of carbohydrate (starch and sugar) in the diet. Reports furnishing definite proof of this with rats have been published during the year from the Alabama and Wisconsin stations, and the latter station has also shown this to be true of dogs. This proof, combined with similar results in earlier studies in other species, leaves no doubt that the higher the carbohydrate content of the diet the higher is the requirement for vitamin B₁. The Alabama station has also shown, in very delicate microscopic studies of the nerves of rats in various stages of vitamin B₁ deficiency, that a chronic mild deficiency in this vitamin B₁ is likely to produce more disastrous results than an acute deficiency. The acute deficiency produces severe neuromuscular symptoms which are readily relieved by the administration of large doses of the vitamin, but long-continued chronic deficiency may result in damage to the nerve tissues that cannot be cured no matter how much of the vitamin is given.

The announcement a year or so ago from the Wisconsin station that the well-known chemical compound nicotinic acid is a B vitamin responsible for the prevention and cure of pellagra was promptly followed by the successful use of pure nicotinic acid and some of its derivatives in the treatment of pellagra. An important byproduct of this discovery has been the proof that riboflavin, another of the B vitamins whose chemical nature is known, is essential for the prevention and cure of certain symptoms often associated with pellagra (chiefly soreness in the angles of the mouth) which do not respond to nicotinic acid. Thus one discovery leads to another, for it was not until nicotinic acid in the pure form had failed to cure all of the symptoms formerly attributed to pellagra that the specific effects of riboflavin deficiency in humans were recognized. Further work by the Wisconsin station has shown that foods containing only fair amounts of nicotinic acid are useless in the treatment of pellagra because the pellagrin is unable to digest the food sufficiently to liberate the nicotinic acid present. For the cure of diseases caused by lack of certain vitamins the use of concentrates of the vitamin in question or of the pure vitamin, if it is available, is often necessary, while for the prevention of the same diseases the right kinds of foods in abundance are usually sufficient. Continued study of the vitamin content of foods is needed from the standpoint of prevention of vitamin-deficiency diseases. Continued research leading to the isolation and synthesis of vitamins is needed from the standpoint of

knowledge of their function and their preparation in pure form for curative use.

An important discovery by the California station is that one of the B vitamins, not yet isolated but present in effective amounts in certain concentrates made from yeast, rice bran, and liver, may be a preventive of premature aging of certain vital organs. Lack of this substance in the diet of young pied (colored) rats was found to cause graying of the hair at an early age, loss of skin elasticity, deterioration of the adrenals and other glands and, in some cases, the development of leg ulcers. All of these old-age symptoms were rapidly cured by the administration of the concentrates mentioned or by injections of large doses of adrenal cortex extract. The effectiveness of the latter suggests that the unknown "antigraying" factor may be necessary for the proper functioning of the adrenal cortex.

Another of the B vitamins whose function is suspected but not actually known as yet is vitamin B₆, the lack of which is associated with a certain type of dermatitis known as acrodynia. Recent work by two groups of investigators at the Wisconsin station suggests that both vitamin B₆ and certain fatty acids are involved in the prevention and cure of the acrodynia. Possibly there is a connection between the two. The station is continuing attempts to identify the remaining unknown factors in the B complex.

Vitamin C (ascorbic acid).—Studies on guinea pigs at the California and Washington stations indicate that pure ascorbic acid is not equal in its protective effects to a corresponding amount of the vitamin furnished by orange or tomato juice. The difference noted by the Washington station investigators was not in the amounts of ascorbic acid in the blood and organs of the guinea pigs, which were alike for both sources of the vitamin, but in the tendency to hemorrhages in the joints—the real scurvy symptoms. These appeared in the animals receiving an amount of pure vitamin C which in the form of orange juice was completely protective. This suggests that it is wise to get one's vitamin C from natural foods rather than to take it as pure ascorbic acid.

Through two cooperative projects, one among three stations in the Northeast (Massachusetts, New York (Cornell), and Rhode Island stations) and the other among five in the Northwest (Washington, Montana, Idaho, Utah, and Oregon stations), considerable information has been secured on the intake and output of vitamin C by young people, chiefly college women. An elaborate investigation at the New York (Cornell) station of the vitamin C requirements of young people has continued along the lines described in the 1937 report (p. 149), and the same plan is being followed with a limited number of subjects in the Northwestern States noted above. At the California (Davis) station elderly people are being studied in a similar way with indications that in older people the cells use up vitamin C more rapidly than in younger people and that the requirement for vitamin C in old age may be greater than is now assumed.

The first detailed report of the New York (Cornell) station vitamin C-requirement study gives values for seven normal adults, five young women and two young men, of whom two required between 70 and 85 mg. of ascorbic acid daily to maintain tissue saturation, three between

85 and 100, and two more than 100 mg. daily. (A full glass of orange juice furnishes about 100 mg. of ascorbic acid.) When calculated in terms of body weight, these values amount to a range of from 1 to 1.6 mg. per kilogram (2.2 pounds) of body weight. In the three subjects already studied by exactly the same method at the Washington station, the requirement ranged from 70 to 90 mg. of ascorbic acid daily, or 1.2 to 1.8 mg. per kilogram of body weight. These values represent the minimum quantity of ascorbic acid, not for the protection of the body against scurvy or any visible sign of vitamin C deficiency, but for the complete saturation of the tissues. How necessary or advantageous it is to keep the body fully stocked with vitamin C has not yet been determined with certainty and is one of the reasons for a continuation of vitamin C studies such as are being carried on in so many of the stations in the hope of simpler and perhaps more dependable tests for vitamin C status and requirements. The efforts of the northwestern group are now being directed chiefly toward determination of the ascorbic acid content of the blood as a more simple measure of vitamin C status and requirements.

As a simple qualitative test for the status of vitamin C nutrition in children, the Maine station has found that the condition of the gums, whether inflamed or not, checks very well with the results of saturation tests for vitamin C. Five of six children with normal gums gave good response to the saturation tests, while 12 of 29 children with inflamed gums gave poor results. An increase in the number of children with inflamed gums from 7 percent in the fall to 25 percent of the same group in the spring showed that many of the children were receiving too little vitamin C in the winter months.

Vitamin interrelationships.—The problem of vitamin requirements is becoming more complicated with accumulating evidence of interrelationships among them, at least if experimental evidence with laboratory animals can safely be applied to human beings. At the California station the effect on rats and dogs of moderately excessive doses of vitamin D has been found to be more toxic than has hitherto been supposed, but an excess of vitamin A at the same time protects against the toxicity. If a diet is abundantly supplied with calcium and phosphorus there is less danger of toxic effects from excess vitamin D. From the Arkansas station likewise comes word that severe depletions of vitamin A render animals more susceptible to extratoxic effects of vitamin D. The Arkansas investigators have also observed that deficiencies in vitamin A, vitamin B, and riboflavin result in losses of vitamin C from various organs of the rat, an animal which does not ordinarily require vitamin C. Hyperthyroidism in rats also depletes the store of vitamin C and to a greater extent if the diet is deficient in vitamin B₁. However, these findings are not of as great concern to the housewife or dietitian in providing vitamins in the diet as to the clinician in prescribing vitamins as supplements to various clinical measures.

MINERAL REQUIREMENTS AND UTILIZATION

Calcium and phosphorus for bone and tissue development and maintenance, and iron and copper for hemoglobin formation in the blood are the mineral elements chiefly considered in judging the adequacy of

the diet. While food analyses give the content of these elements in different foods there still remain questions of the extent of their utilization in the different forms in which they are taken into the body, and the actual amounts needed for optimal nutrition, the state which cannot be bettered. These questions, particularly as applied to calcium and iron are receiving attention at the experiment stations.

Calcium.—The comparatively low availability of calcium in spinach in comparison with other green vegetables and calcium salts, as determined in feeding experiments on rats and by certain chemical tests, has been noted on page 191 and brief reference was made to calcium studies of the Illinois and Oregon stations with human subjects. A long-continued study of the Illinois station in which small groups of preschool children, five girls and five boys, served as subjects, led to some rather surprising conclusions. The finding that calcium was equally effective in milk and in dicalcium phosphate (the salt commonly recommended by physicians as a supplement to food calcium) was to be expected, but that only about 20 percent of the calcium from either source was utilized by the body was somewhat of a surprise in view of the fact that rats are capable of utilizing calcium almost completely. However, the smallest amount of calcium required for the highest retentions (intake minus output) in these children was quite a bit lower than the commonly adopted standards. In terms of milk, the Illinois investigators stated in their report—

Obviously if these children had been receiving a diet generous in vegetables (such as is usually recommended for children of their age) it is altogether probable that the addition of a pint of milk easily would have supplied enough calcium to meet the requirements.

As a preliminary measure these children had been given generous doses of dicalcium phosphate during a period of several weeks in order to make up for any deficiencies in the past and to start the experiment with a maximum storage of calcium. Thus the estimate of a pint of milk a day can safely be used only for children who are not low in calcium to start with. Commenting on the equal effectiveness of calcium in dicalcium phosphate and in milk, the Illinois investigators point out that except in the cases of children who are allergic to milk or for whom it is difficult to secure enough milk the use of a calcium salt either as a substitute for or supplement to milk—

is economically unsound. Money invested in dicalcium phosphate buys only two nutrients, calcium and phosphorus, whereas money invested in milk buys a portion of almost all of the various nutrients required by the human body.

In another investigation at the University of Illinois a man was found to utilize the calcium in milk and in calcium gluconate equally well but, as in the case of children, only to the extent of about 20 percent. In estimating requirements for adults the criterion used was the quantity of calcium required for equilibrium, a balance between intake and output, rather than for storage. This requirement was met in the single subject studied by about 40 gm. of skim-milk powder furnishing 540 mg. of calcium in addition to about 195 mg. in the basal diet. The total calcium, 735 mg., amounts to about 9.2 mg. per kilogram (2.2 pounds) of body weight as the minimum calcium requirement for maintenance in an adult.

Iron and copper.—The function of iron and copper in the prevention and cure of nutritional anemia was discussed in the 1937 report (pp. 144, 145). Most of the experiment station research in this field has been carried out on rats on the assumption that human beings would respond in a similar manner. The Mississippi station has recently put this to the test by the simple means of feeding iron and copper salts to a man suffering from chronic anemia as the result of having taken all his life no other food than milk. The 3 quarts of raw milk a day, which he had been in the custom of taking, had apparently protected him against obvious symptoms of scurvy, but he had become incapacitated for work because of his anemic condition.

During an observation period of 6 weeks before treatment was begun the hemoglobin content of the blood of this subject averaged 3.7 gm. per 100 cc. as compared with normal values of about 14 gm. per 100 cc. The red blood cell content was also low. The treatment consisted at first simply in supplementing the milk diet with a solution of iron and copper salts furnishing 150 mg. of iron and 6 mg. of copper a day. Later, after improvement had begun, citrus-fruit juices were added to the diet to increase the vitamin C intake, and a cup of pot liquor two or three times a week for additional iron and copper. With no other treatment the hemoglobin content of the blood rose to 12.9 gm. per 100 cc. in 4 months and to 13.8 gm. in 6 months. Along with improvement in the blood picture there was such marked improvement in the subject's physical condition that he was able to work again.

The striking results obtained with this subject add weight to the belief based upon animal experimentation that a certain type of anemia is produced by lack of iron and copper and requires these mineral elements for the prevention and cure of the condition. Fortunately, copper is needed in such small amounts and is present in so many foods that for people on a mixed diet iron alone need be considered. Copper metabolism studies at the Nebraska station indicate that as small an amount of copper as 2 mg. a day is enough for maintenance and that larger amounts are stored for future use.

Iron-deficiency anemia among children may be a more serious problem than is generally supposed. Recent studies by the Florida station have shown that the condition may continue in a chronic stage without the appearance of easily recognizable symptoms until the hemoglobin has been reduced as much as 50 percent. Among nearly 900 school and preschool children tested by the Florida investigators, one of whom was a physician, 50 percent were definitely anemic as indicated by hemoglobin values and red-cell counts and 31 percent were on the border line. About 400 of the children were in a single county representing quite different soil and occupational types. The hemoglobin values for these children ranged from 4.35 to 14.05 gm. per 100 cc. In school districts on the coast, where fishing and general farming predominated, less than 5 percent of the children were anemic, in general- and truck-farming areas 15 percent, and in certain other districts as high as 60 percent were anemic.

An even higher percentage of women examined during pregnancy were found by the Florida investigators to be anemic. Hemoglobin values as low as 35 percent were frequently obtained. In all cases

routine iron treatment (sometimes with hydrochloric acid) raised the low values to normal.

As with most dietary-deficiency diseases, this type of anemia is more easily prevented than cured by foods rich in the deficient substance, in this case, iron (and copper). In the Florida study with children, the addition of iron-rich foods to the diet failed to bring the hemoglobin back to normal in 3 months when the anemia was severe, although iron salts corrected the condition in a much shorter time.

From an earlier study of the food consumption of boys and girls in agricultural high-school dormitories in Mississippi and preliminary blood studies in young men and women just after enrolling in colleges in the State, it has been concluded by Mississippi station investigators that the girls are more often below standard in various nutrients, particularly iron, than the boys. As it is now thought that the iron requirements of women are even higher than of men, it is particularly important that they should receive plenty of iron-rich foods in order to prevent the development of a condition that is so much more difficult to cure.

DIETARY HABITS AND INDICES OF NUTRITION

The adequacy of family diets is usually determined from records of food consumption during a period of time by calculating the quantities of the essential nutrients in the diets from the most reliable table of food composition and comparing them with the needs of the family, as estimated from existing standards. In a series of studies by the South Carolina station of the types and adequacy of farm-family diets in different sections of the State, the diets as thus calculated were given ratings of good, fair, or poor, according to the extent to which they met these standards. The second of these studies, in the Coastal Plains area of the State, has been completed and the results made available in a station bulletin (No. 319). Only 95 of the 214 white-family diets studied and 31 of the 183 Negro diets could be classified as nutritionally good, while 89 white and 71 Negro diets were fair, and 30 white and 81 Negro diets were poor. According to the report—

though lack of money and resources was responsible for many of the poorly balanced diets found in the South Carolina study, lack of knowledge and failure to plan well were equally evident reasons for having diets that were less than adequate.

As an aid to better planning and the selection of good diets, the amounts of some of the more common foods used per person per week in the diets of the different grades were pictured graphically in the bulletin. Studies of this type reported in easily understandable terms are of great educational value, for, as stated in an editorial comment on the bulletin in one of the newspapers of the State: "It is only when the population possesses knowledge of food values and the ability to plan well that their resources can be made to serve their needs."

Another method now coming into use for judging the adequacy over a long period of time of diets of certain patterns is to compare family food-consumption records with the nutritional status of the

individual members of the family. This is a costly, time-consuming method but well worth undertaking if personnel and funds for rather expensive equipment are available. The Pennsylvania station is conducting such an investigation by methods which have been discussed at considerable length in one of the series of Pennsylvania State College Studies (No. 4). Among the methods being used is the determination of the density of the bones as a measure of calcification by tracing the density in X-ray films of the bone from one fixed point to another with a recording microphotometer adapted by the Pennsylvania investigators for use with a photronic cell. The apparatus as modified is thought to have wide applications for bone and tooth density measurements.

Certain body measurements have long been used as one measure of nutritional status of children of different ages without much regard to possible regional or racial differences. The Texas station published during the year the final report (Bul. 567) of an investigation of the relative size, body build, and rate of growth of Mexican, white, and Negro children in the public schools of San Antonio. The differences among the three groups were such as to indicate very conclusively that growth standards for white children should not be used for Mexican or Negro children, although more studies are needed with standardized technique to determine the extent to which various factors affect growth of individuals of the same race in different localities and different races in the same locality.

The three regional cooperative projects dealing with various phases of the problem of nutritional status and requirements of young people, as noted in the 1937 report (pp. 142, 143) are continuing, with the accumulation of data on anthropometric measurements, basal metabolism, blood chemistry, dietary habits, and mineral, nitrogen, and vitamin C metabolism, which should be of considerable value in establishing more reliable standards of nutritional status and requirements—consumer problems of vital interest.

TEXTILES AND CLOTHING

Consumer preferences for articles of clothing and household textiles are receiving attention in experiment station research from the standpoint of household economics and budget planning and consumer information concerning quality. The latter involves laboratory tests to check the reliability of the information available.

Factors affecting consumer choice in the purchase of "silk" street dresses and yard goods were studied by the Minnesota station, with the conclusion that "reliable standards and dependable labeling are needed as guides to the quality of both workmanship and materials." Studies by the Missouri station, noted in a preliminary stage in the 1938 report, on consumer preferences for selected articles of clothing (house dresses, afternoon dresses, slips, and hose) and of household textiles (sheets, blankets, window curtains, and towels) have been completed with the analysis of nearly 3,000 returned questionnaires on clothing and 4,000 on household textiles. The majority of the participating women were from rural areas making their purchases in small towns and cities. For each commodity the information reported included, in addition to other items, demand for specific qualities, effect of income on practices with range in prices paid,

and difficulties encountered in buying and with wearing qualities. The difficulties encountered are more or less familiar to consumers, but their enumeration in the bulletins reporting these studies (Res. Buls. 300 and 301) may call the attention of manufacturers and wholesale buyers to certain practices that should be corrected. The price ranges noted should be of help to consumers in budgeting their expenditures for clothing and household textiles, although giving no indication as to the value received for the different prices spent.

The extent to which authentic information is available to purchasers of textile fabrics concerning the fibers (cotton, silk, and different types of rayon) of which the fabrics are composed has been investigated by the Kansas station through comparisons of the composition of the selected fabrics, as determined by laboratory tests, with the information as to composition available to the purchaser. A total of 268 fabrics, about equally divided between single- and mixed-fiber composition, was secured in 18 stores in 7 towns and cities of the Midwest. In many cases the fabrics were not labeled as to fiber content and no information could be secured from the salesmen. Among the fabrics that were labeled or concerning which the salesmen furnished some information, many more were described inaccurately than accurately. The inaccuracies were chiefly in the three types of rayon fabrics—acetate, cuprammonium, and viscose rayon.

The announcement was made in the 1937 report (pp. 152–153) of a cooperative textile project among several of the Northeastern States for the purpose of comparing performance during wear of fabrics used in the home construction of women's and children's garments with predicted performance from laboratory tests of the original material. All materials collected in the various States are sent to the textile laboratory of Pennsylvania State College where they are being analyzed by standard methods with improved equipment, including the newest model of twist tester to distinguish between various types of crepes, a flexometer to determine crease resistance, and a hydrostatic machine to determine waterproofing. By June 1, 1939, a total of 754 fabrics had been received at the laboratory, including 81 wool, 79 silk, 260 cotton, 244 rayon and rayon mixtures, 9 linen, and 81 miscellaneous mixtures. Comments at that time by the Pennsylvania workers were that "more accurate sales information on the probable durability of textile fabrics is needed by consumers."

THE HOUSE AND ITS EQUIPMENT

Kitchen planning.—The kitchen has received more attention than other parts of the house in agricultural experiment station research, for it is not only the place where the farm homemaker spends the greater share of her working hours but often the center of various other home activities in which all of the members of the family participate. In times past farm kitchens were planned without much regard for efficiency either in the saving of steps for the work to be done or in the planning of space for different types of activity.

The first and most important step in kitchen planning is the arrangement or rearrangement of work centers for greatest efficiency. The most recent experiment station contributions along this line have been from the New York (Cornell) and Oregon stations. Unfortunately, no one standard for kitchen size, shape, and arrangement can be set up. Often the only possible change in existing kitchens is in the rearrange-

ment of working surfaces and equipment and the provision of more convenient and adequate storage space. The latter is particularly necessary when the important step is taken of abandoning the pantry because of its inconvenience for storing equipment and materials in everyday use.

Special attention has been given in the New York studies to kitchen rearrangement and procedures for making existing space in kitchens of odd sizes and shapes more convenient through shelves, drawers, and hanging racks adapted to the various utensils and equipment for which space must be provided. Useful suggestions with photographs of actual arrangements in New York State home kitchens and diagrams of various space-saving devices are given in one of the series of Cornell Bulletins for Homemakers (No. 398).

At the Oregon station emphasis has been given to the equipment, arrangement, and minimum dimensions of kitchens that will make adequate provision for the needs of farm families in the section of the State in which the work was done. Conferences were held with a number of farm homemakers concerning the various uses to which their kitchens are put and the equipment, large and small, for which space must be provided. On the basis of the information thus secured and a number of laboratory tests, plans were developed to meet various situations. These have been published in a technical bulletin of the station (No. 356) and more briefly in a circular (No. 131) which includes working designs for cabinets, floor plans, minimum dimensions for free floor spaces, and descriptions of the centers needed in the average farm kitchen for food preparation, dining, ironing, planning, and child care and play.

Floor finishes.—The covering of the kitchen floor, the finishing of the other floors, and the general care of the woodwork throughout the house are problems which are receiving attention at the Rhode Island station and to some extent at the New York (Cornell) station. A motor-driven apparatus has been devised and is in use at the Rhode Island station for testing the serviceability of various floor finishes. The work is still in progress, but a mimeographed publication (Misc. Pub. No. 3), giving practical information, based on the results thus far obtained, for the guidance of homemakers in the choice, application, and care of finishes, has been issued. Special emphasis is given to penetrating seal finishes for wood floors, and water-emulsion waxes for other wood and linoleum coverings with simple household tests for quality in the latter. The Cornell study is dealing for the present with the durability of, and suitable finishes for, linoleum of the felt-back type.

Kerosene stoves.—The Maine station study on kerosene stoves, noted in the 1937 report (pp. 153-154) from preliminary work, has been completed and the results have been made available in a station bulletin (No. 394) in which the material is so arranged as to be of service to other investigators, teachers of household equipment, extension workers, and manufacturers. Prospective purchasers and users of kerosene stoves may find more useful an extension bulletin (No. 251) which gives much practical information based upon the station study, through answers to a series of questions such as any housewife buying or using a kerosene stove might ask.

Gas stoves.—Further studies by the Nebraska station of selected types of gas stoves have resulted in somewhat more definite specifica-

tions (Res. Bul. 111) for optimum requirements of the cooking tops and ovens than were noted in the 1937 report (p. 154). Special emphasis was given to the specification that the cooking top burner assemblies should produce no carbon monoxide. Two of the six stoves tested did produce more carbon monoxide than allowable under the standards of the American Gas Association Testing Laboratory and in both cases the cause was found to be the inability of the burners to handle properly higher gas rates than 8 cubic feet per hour. In view of the grave danger involved in carbon monoxide production, this point should be thoroughly investigated with reference to the prevailing gas pressure when purchasing a gas stove. Knowledge of the burner capacity is helpful not only for top burners but also for oven burners inasmuch as burners made for a larger capacity than needed to heat the oven cannot maintain a low enough temperature to meet all baking needs.

Consumer demand for such specifications as have been developed by the Maine station for kerosene stoves and the Nebraska station for gas stoves will do a great deal to improve the quality and uniformity of the equipment. Similar studies of some of the newer types of electric equipment are also being carried on at several of the stations.

Electric mixers and beaters.—A progress report from the Indiana station on small electric mixers states that the greatest difficulty in the use of mixers as now manufactured is not to overmix the product. Most of the small mixers thus far tested by the station can be used to mix both sponge and butter cakes. In general the best results are obtained with recipes requiring considerable mixing. In creaming, maximum volumes are obtained at the lower speeds. As a result of conferences of research workers in equipment from the experiment stations and the Bureau of Home Economics some co-operative work on various types of equipment is being undertaken. One of the first examples was a cooperative arrangement between the Iowa and Nebraska stations on electric mixers. This involves certain changes in equipment to be made at the Nebraska station and tested in a practical way at the Iowa station. The work at the Indiana station is now being made a part of this cooperative project.

Electric roasters.—This is a still newer piece of electric equipment to receive attention in experiment station research at Iowa and Virginia. The work is in the early stages and it may be some time before standard specifications can be set up. Nevertheless, certain conclusions drawn by the Virginia station after a rather complete examination of six of the most popular electric roasters now on the market may be of value to the housewife who wonders whether she would be justified in buying this piece of equipment. The Virginia station reports that the results thus far obtained indicate that all of the roasters are slow to preheat and must be turned on a considerable time before heating, but the thermostatic control is about the same as in the electric range and the current consumption no greater or even a little less. In general, according to the Virginia investigator—

in small families the roaster can be used for all of the cooking but for larger farm families, especially where a wood or coal range is maintained, the roaster must be considered a supplementary appliance for cooking. It is particularly useful in the summertime when heat from the stove is detrimental, also where electric cookery is desired and the high-priced electric range cannot be afforded.

Cooking utensils.—One important and often neglected item in the use of any cooking equipment, whether it be a kerosene stove or an electric roaster, is the effect of the material of which the cooking utensils are made. According to investigators at the Maine station who are studying the effect of method of heat application on flavor and texture of baked foods—

the cooking of foods is not solely a problem of heating the mass as quickly as possible. On the contrary, a definite rate of heat absorption, not too fast or too slow, is necessary to bake certain foods, particularly batters and doughs.

If foods are to be baked satisfactorily in glass pans, the oven temperature should be lower than for metal pans to obtain the same rate of heat absorption. The extent to which the temperature should be lowered depends on the amount of material to be heated. With very small amounts the same temperature can be used for both glass and metal pans, but as the amount increases the temperature satisfactory for tin should be correspondingly lowered.

FAMILY ECONOMICS AND HOME MANAGEMENT

The economic problems of the family in rural homes include not only the management of the family's material resources but often the management of the time of the homemaker. For wise management of finances it is advisable to take into consideration the farm enterprise as well as the home, and for this reason farm economists and home economists are beginning to get together in joint studies of the factors affecting the expenditures of farm families. The problem of securing a greater cash income as well as a comfortable living from the farm is a serious one in sections of the country where the farm income is meager and the opportunities for gainful employment for the younger generation are slight. This problem is also receiving attention in experiment station research.

Family expenditures.—Reports from several of the stations on expenditures of farm families are of special interest to the families from whom the records were obtained and others in the same localities and of general interest in the comparisons they afford of the percentage expenditures for the different items that make up family living. As an illustration, reports of family-living studies in Arkansas, Maryland, and North Dakota showed very similar proportional allotments of the family income to clothing—14.1, 15, and 15.2 percent, respectively—but those for food were quite unlike—23.2, 41, and 29.2 percent, respectively.

The rather uniform percentage expenditures for medical care, 5.7, 7.7, and 5 percent, respectively, are of interest also in comparison with corresponding figures obtained in the first two of a series of studies by the Arkansas station on sickness and medical care among different population groups in the State. Data from the first study of white families in the Ozark section were given in the 1938 report (pp. 156-157). The report of the second study among the Negro population in a Delta area of the State as published in a station bulletin (No. 372) shows some interesting contrasts. The white families in the first study used on the average 6.5 percent and the Negro families in the second study 4.3 percent of their cash expenditures on medical care. Thus in five different studies in three States the percentage of total expenditures (which varied widely) used for medical care varied

within the comparatively narrow limits of from 4.3 to 7.7 percent. The most striking difference in proportional expenditures for various health services in the two Arkansas studies was in unprescribed medicines, which amounted to about 20 percent of the total health expenditures for white families and 42 percent for the Negro families.

Increasing cash incomes of farm families.—One of the socioeconomic problems of farm families in many sections of the country is the lack of cash not only for the bare essentials of family living but for the little extras needed, especially by young women at home on the farm. Opportunities for cash incomes for farm women include full-time jobs in rural communities near larger cities, home industries in localities with tourist trade, home demonstration and farm markets, local industries in rural areas, and no opportunities in many sections. A study by the Rhode Island station of methods by which married women on full-time jobs manage to carry on their homemaking activities showed that labor-saving equipment, help from other members of the family, and the greater use of commercial services for foods and laundering make it possible for these women to carry on successfully the double responsibility to home and outside work when it is necessary to supplement the husband's inadequate income. In spite of the fact that nearly 60 percent of the women reported they were working for necessities, 62 percent said they enjoyed their work and would not like to give it up. Thirty-eight percent felt that the pressure of need made their job decidedly necessary, but would gladly give it up if it were financially possible.

In Arkansas station studies cash receipts of home demonstration and souvenir markets were found to contribute a considerable proportion of the cash income of some rural families. The median proportion of the family income received from the home demonstration markets was 25.4 percent. Handicraft sales contributed an average of 21.6 percent of the cash income of families engaged in this enterprise.

In Mississippi a greater cash income for rural girls is considered to be a community problem. In a random sample of white women in rural areas of two poor agricultural counties of the State the Mississippi station found that 93 of 178 single women 16 years of age and over had had almost no gainful work during the year of study. Among this group were 63 between the ages of 17 and 35 years of whom 37 had no cash earnings and 26 small earnings averaging \$28 a year. It is pointed out that the brothers of these young women are generally given a crop to work, with the experience and benefit of handling a little money of their own, but the girls remain in a status similar to that of children in the family.

FAMILY RELATIONSHIPS

Research in this field is much needed in rural communities, but until recently has been given little attention in experiment station research. A beginning has been made by the Nebraska station in a study of personality development in farm, small town, and city children. The reports of this study (Res. Buls. 106 and 114) have brought out differences in home settings (farm, small town, and city) with respect to their effect on personality development of the children growing up in them. These reveal certain weaknesses in the

farm setting as compared with the small town, but particularly with the urban setting. In scholastic aptitude as indicated by the Otis I. Q. tests the city group ranked highest and the farm group lowest for both boys and girls. In social relationships, as shown by tests of resourcefulness in group situations and ethical judgment, the farm group ranked lowest, with the city and small-town group about equal. The differences were almost wholly with the girls and are attributed in part to fewer opportunities for social contacts. The farm group ranked higher than the town group but lower than the city group in personal adjustment and independence of decision concerning personal problems and difficulties and higher than the town group but not significantly different from the city group in attitude toward home life.

These intangible problems of family living and particularly of the best development of the children in rural homes are even more difficult to meet than the tangible "consumer problems" which have been discussed. The Nebraska investigator, however, expresses the belief that—

as parents and prospective parents are led to realize the importance of congenial, confidential, and affectionate relationships between parents and children, and of the utilization of family leisure in wholesome and stimulating joint recreational activities there should result also a rise in the general level of personality adjustment of rural young people.

RURAL SOCIAL SCIENCE

CONTENTS

	Page		Page
Agricultural economics	220	Agricultural economics—Continued.	
Soil conservation and land use	220	Miscellaneous	232
Marketing	222	Rural sociology	233
Costs of production	225	Population studies	233
Factors affecting income	226	Standards of living	236
Land prices, transfers, and tenure	228	Rural welfare	237
Taxation and use of tax funds	229	Rural-urban relations	238
Credit	231	Social groups	240

Need of information in connection with the various action programs of the Department and the State and county planning boards and committees largely determined the character of the research of the State experiment stations in agricultural economics during the year. As in past years, much of the work was carried on in cooperation with various divisions of the Bureau of Agricultural Economics, the Forest Service, and other bureaus and agencies of the Department, the Department of the Interior, the Federal land banks, the Works Progress Administration, and State agencies. Studies in soil conservation and erosion, agricultural adjustments, marketing, and farm management were emphasized, and additional investigations were made on taxation, tenancy, credit, land classification, types of farming, factors affecting income, costs of production, and other phases having to do with economic problems of the farmers of the several States.

Of the 50 State experiment stations, some 29 had active projects in rural sociological research in 1939. Although a number of projects were completed and others initiated during the year, the total under way remained practically the same as in the previous year. Some 25

bulletins were issued by the stations during the year. The work was organized in separate departments of rural sociology in 11 stations, in joint departments of agricultural economics and rural sociology in 9, and in 9 others rural sociology was attached to the division of agricultural economics.

The rural sociological research of the stations has been aided materially in recent years by the work of Federal agencies. In the Bureau of Agricultural Economics, the Division of Farm Population and Rural Welfare began Nation-wide studies of the human problems involved in county planning, subsistence homesteads, and cultural anthropology. Special inquiries in this latter field include cultural history, population make-up, human geography, formal and informal associations, rural economy, city and national influences on the farm mind, the family circle, religion, medicine, and typical individual life histories.

State research in rural sociology has also received much impetus during the past few years from the cooperation of the Division of Social Research, Works Progress Administration, in emergency studies of relief and related problems. As a result of these studies, the W. P. A. published during the year six monographs dealing directly with rural problems, such as rural relief, rural youth, farm hazards in the drought area, migrant families, and rural migration.

AGRICULTURAL ECONOMICS

The following items, based on publications of the stations during the year and notes from the station directors, have been selected to illustrate the types of studies being made and some of the findings.

SOIL CONSERVATION AND LAND USE

Soil conservation.—A study by the Pennsylvania station in cooperation with the Department (B.A.E. and S.C.S.) of 344 farms in the Crooked Creek conservation demonstration area showed that 25 to 75 percent of the original topsoil had been lost from nearly 50 percent of the total farm land and over 75 percent from over 19 percent of the land. Forty-one of the farms lacked from \$600 to \$1,000 of showing any labor income while 25 showed labor incomes of \$600 to over \$1,000. The average for all farms was —\$119. The farms above the average in number of livestock, crop yields, livestock production, and efficiency of man labor had a labor income of \$304 as compared with —\$332 for the farms on which these factors were all below the average.

The New Hampshire station in a study in cooperation with the Department (B.A.E. and A.A.A.) found that the number of farms in 12 representative counties of the State enrolled in the agricultural conservation programs increased from 342, representing 34 percent of the land in farms in 1936, to 664, representing 59 percent, in 1937. The percentages of farms of different types enrolled in 1937 were active commercial farms over 84 percent, less active commercial farms 53, subsistence farms 34, and residence farms slightly over 8 percent. Of the enrolled farms 91.3 percent of the active commercial, 79.7 of the less active commercial, 61.2 of the subsistence, and 28 percent of the residence farms qualified for payments under the program.

The West Virginia station in cooperation with the Department (S.C.S. and B.A.E.) found that on 187 farms in the Jackson County soil conservation demonstration area the average acreage in farms increased 3 acres in 1936, the land cropped 0.3 acre, permanent pastures 4 acres, and woods not pastured $3\frac{1}{2}$ acres. The acreage in erosion- and semi-erosion-resistant crops increased $2\frac{1}{2}$ and $1\frac{1}{2}$ percent, respectively, and those in nonresistant crops decreased 4 percent. Animal units per farm increased by four-tenths of a unit. The average labor income increased \$102 and total operators' earnings (labor income plus nonfarm receipts and value of perquisites) \$166.

A study of the socioeconomic phases of soil conservation in the Tarkio Creek area of Iowa was made by the Iowa station.

Tobacco lands in Maryland.—A study by the Maryland station in cooperation with the Department (B.A.E.) of tobacco lands in the southern part of the State showed that while almost 50 percent of the tillable land is good tobacco soil only about 14 percent is in tobacco. The average labor income on the 40 farms with the least tillable land idle (17 percent) was 55 percent greater than that for the 40 farms with the most idle land (66 percent). The percentage of tillable land was nearly the same in both groups, and each could have doubled its tobacco acreage. The study showed that diversification of crops is profitable since the farms with the less emphasis on tobacco were the more successful. Diversification did not lower the yields or quality of tobacco and encouraged livestock production by allowing more feed crops to be grown.

Range lands.—The Wyoming station made an extensive survey of the vegetative composition, density, grazing capacity, and grazing-land values in the Red Desert area of that State. The Utah station also made a similar study of the land ownership, vegetation, forage supply, grazing capacity, soil erosion, and the organization of farms and ranches in the Uinta Basin of Utah. The findings of the Nevada station of the cost of production of sheep and cattle under widely varying conditions emphasized the fact that the stability of ranch earning power and ranch land values for loans and taxation depends upon the relationship between privately owned ranch land and publicly owned range lands. According to the station the disturbance of this relationship by attaching grazing privileges on public lands to livestock instead of hay-producing ranch land may render the ranch land in certain localities practically valueless by taking away much of its earning power. The station, in cooperation with the several bureaus of the Department and the Department of the Interior, the Federal land bank, and other State and Federal agencies, began a study of the carrying capacity and use of range lands in Elko County with a view to determining the relationship between land values and grazing privileges. This study is deemed by the station to be of especial importance at this time when Federal agencies are attempting to shape plans for the administration of public lands so that soils may be conserved, range forage used, and at the same time growth preserved and improved and land values and tax structures stabilized.

Land use in Ohio.—A study by the Ohio station in Clinton County showed that the cropping practices on only 23 percent of the farms were such as would maintain the productivity of the soil. Sixty

percent of the soil building was contributed by legume sod and cover crops. Larger labor incomes were obtained on the farms where the soils were being maintained.

Types of farming.—Reports on type-of-farming studies were published by the West Virginia, Iowa, Tennessee, New York (Cornell), and New Mexico stations. Similar studies were in progress in a number of other States. Most of such studies, both completed and in progress, are in cooperation with the Department (B.A.E.).

MARKETING

Fruits and vegetables.—In a study of the production and marketing problems facing the grapefruit industry, the Arizona station compiled data showing that the production of grapefruit in the United States increased from 339,000 tons in 1925 to 1,200,000 tons in 1937, with a probable production based on plantings of 1,380,000 tons in 1943, and that production in Arizona increased from 5,000 tons in 1925 to 81,000 tons in 1937 with a probable yield of 190,000 tons in 1943. During the period 1925–28 the returns to Arizona growers were more than \$70 per ton on the trees while in 1937 they did not exceed \$6 per ton. If production and marketing in 1943 are to be kept to the averages for 1935–36, it is estimated that either 56,000 acres of trees in the continental United States must be removed or about 400,000 tons of fruit must be kept off the market annually by being destroyed, distributed by relief agencies, or absorbed through new uses. In order for exports to take up the surplus, the net exports of 1936 would have to be increased eightfold. Purchases by the Federal Surplus Commodities Corporation approximated 117,000 tons in terms of fresh fruit during the year ended June 30, 1937, and 30,000 tons during 1938.

The New York (Cornell) station published information on the marketing of fruits and vegetables in New York City and the production and marketing of cauliflower, lettuce, and celery; the Iowa station on the marketing of cantaloups; and the Kentucky station on the supply of fruits and vegetables in Louisville, and on the wholesale fruit and vegetable markets of that city.

Two studies were made by the California station on the marketing of pears. The first dealt with the factors affecting the volume and price of the United States and California fresh-pear exports to the United Kingdom. It showed that while the annual per capita consumption in the United Kingdom has remained practically constant during the last 15 years, there has been an increase during the January–June period and a decline during the other 6 months. It also brought out the fact that Pacific coast producers of the United States are encountering increased competition from other countries, especially Australia, New Zealand, and South Africa, which enjoy British Empire preferential treatment. The second study, which dealt particularly with prices of California Bartlett pears, showed that variations in annual average prices depend largely on nonagricultural income in the United States, Pacific coast fresh shipments of all varieties, and the volume of California Bartlett shipments in relation to other shipments during the Bartlett shipping season.

Eggs.—A study by the Maryland station of sales of eggs to a distributor on the United States graded basis and to hucksters, retailers,

wholesalers, and directly to consumers on a nongraded basis showed that the average net prices received by the two methods were practically the same. The station states that—

it is profitable for a producer of high quality eggs to sell them on a graded basis, whereas it is questionable if producers of low quality eggs can sell them profitably on such a basis.

Dairy production.—The Maine station, in a study based on data from milk distributors in the Portland, Waterville, and Bangor areas and seven smaller districts, found that the cost of products constituted nearly 60 cents per dollar of sales. Distribution costs, including interest on capital at 5 percent, were 43 cents for four large distributors and 30 cents for the smaller distributors. The distribution costs averaged 4.36 cents per quart, of which about 50 percent was for labor. Plant costs averaged 36 percent, containers 5, selling and delivery 51, and administration 8 percent. The four large distributors in the Portland market delivered on retail routes an equivalent of 303 quarts of milk daily per route at an average cost of \$2.94 per 100 quarts. The other distributors delivered an equivalent of 130 quarts at an average cost of \$1.44 for the larger volumes and \$2.13 for the smaller volumes.

The New York (Cornell) station in a study of milk distribution by 92 producer-retailers found that the average sales were slightly less than 350 quarts of milk equivalent daily, valued at \$37. The average cost of distribution was 4 cents per quart, of which 50 percent was for labor. Volume of business, labor efficiency, compactness of routes, size of load, and capital efficiency were important factors affecting costs and profits.

Based on a study of 12 cartage routes in the Southwick-Agawam area of the Springfield, Mass., milkshed, the Massachusetts station made suggestions for the reorganization of existing routes into four routes and the establishment of five cartage rate zones. Under the reorganized routes the total route mileage would be reduced from 270 to 167 miles, the actual collection mileage from 142 to 98 miles, the deadheading mileage from 128 to 69 miles, and the average cost per 100 pounds of milk from 33.4 cents to 24.2 cents. The five suggested zone rates vary from 15 to 35 cents per 100 pounds of milk with an additional 5 cents for off-route producers, the most common rate being 20 to 25 cents. Under the existing organization there were 11 rates varying from 20 to over 46½ cents, the most common rate being 35 cents. It is estimated that the lower rates would result in an average saving of \$26 per year per producer.

The Massachusetts station also found that to establish stability in prices under milk-price control a rather definite ratio should exist between the prices of milk sold as fluid milk and that sold as cream. Observations over a period of 15 years showed that the year in that State may be divided into two very characteristic periods—the first from May to October with a ratio of about 195 and the second from November to April with a ratio of about 175—and that stability may be maintained if the price paid producers for fluid milk is set at not over twice the price paid for cream during the period May through October.

The Iowa station, in a report on the post World War marketing of butter, discussed, and made an economic appraisal of, the develop-

ment and changes on the basis of individual large companies, it being recognized that each company had more or less control over a segment of the consuming public through consumers' preferences developed by branding and advertising.

Cotton.—Several stations in cooperation with the Department (B.A.E.) studied the quality of cotton produced and the prices received by producers for different grades and staple lengths. The study of the North Carolina station covering the cotton crop years 1928–36 showed that while there was little, if any, increase in grade, there was an increase of 1.38-sixteenths of an inch in average staple length. In 1936, 13 percent of the staple was less than fifteen-sixteenths of an inch and 85 percent fifteen-sixteenths to $1\frac{1}{16}$ inches as compared with 80 and 19 percent, respectively, in 1928. Prices to growers reflected only 18.8 percent of central-market premiums for grades above Middling and 59.1 percent of those for staple lengths of more than seven-eighths of an inch. Discounts for lower grades averaged 64.4 percent and for short staples 14.9 percent. While the average production 1928–36 was approximately one-half of the consumption of the mills of the State, in 1936 it was less than one-third.

Cooperative marketing.—The Missouri station found that the expenses of the 161 cooperative exchanges and elevators in Missouri in 1935 varied from \$2 to over \$13 per \$100 of sales, averaging nearly \$6, which was relatively low compared to those of retailers of the State. Approximately 50 percent of the expenses were for labor and management, 20 for fixed property, 10 for general expenses, and 5 percent each for inventory, credit, and net trucking expenses. Two important factors regarding small associations were brought out—(1) relative efficiency rather than size of the association determines the level of each operating expense per unit of sales, and (2) while larger operating ratios are more common in large associations, they are also possible in associations with sales amounting to less than \$50,000.

According to a study of the Washington station, there were 260 cooperative organizations in the State in 1936 with an active membership of 62,000 persons. Of these associations, 170 were organized for marketing farm products and 90 for purchasing production and consumption supplies. The greatest success was achieved where (1) previous methods of marketing involved unnecessary duplication in physical facilities and selling efforts; (2) the commodities handled were principally those which purchasers desire in large volume and can be standardized as to quality; (3) one staple product or group of products had furnished an assured volume of business and other products had been handled largely as side lines; (4) expenses had been low in relation to volume of sales and credit limited so that there was little or no risk; (5) leadership had been capable and enthusiastic; (6) managers had been carefully selected; (7) financing had been adequate but there had been no unnecessary expensive plants; (8) payment of patronage dividends had been used rather than giving all the advantages of cooperation immediately by the lowest possible prices; and (9) in the case of feeds and petroleum products, the chain-store method of combining wholesaling or jobbing with retailing functions in the same or closely affiliated organizations had been followed.

In June 1937 there were 354 cooperative associations in South Dakota with over 71,800 members and nearly 124,300 patrons of whom

59,500 were members, according to a study by the South Dakota station. About 78 percent of the associations were organized primarily for marketing, and 22 percent for purchasing, farm supplies. The total business in 1935-36 amounted to nearly \$27,000,000. The operating expenses averaged 8.6 cents per dollar of sales, and ranged from 5.7 cents for livestock-shipping associations to 15.1 cents for lumber associations.

A study by the Iowa station of 48 of the 195 community livestock auctions active in Iowa in 1936 showed that larger numbers of cattle and calves were sold than of hogs or sheep. Farmers consigned 64 percent of the cattle, 73 percent of the hogs, and 84 percent of the sheep and lambs, and purchased 46 percent of the cattle and calves, 68 percent of the hogs, and 50 percent of the sheep and lambs. Dealers purchased 46, 30, and 47 percent, respectively, and packers 8, 2, and 3 percent, respectively. As compared with conveniently located public stockyards, the expense of selling small numbers of animals of low value was less at the auctions and higher for large numbers of animals of high value. A study of livestock auctions was also made by the Georgia station.

The Minnesota station showed that from 1919 to 1936 the number of livestock-shipping associations decreased from 655 to 262, the number of members from 124,000 to 45,000, the average shipments per association from 58 to 49 cars, and the amount of livestock handled from 61 to 13 percent of the total marketings by Minnesota farmers. Increased mileage of hard-surfaced roads, increased number and efficiency of trucks, improved grade standards, and availability of market information were the chief causes of decline in the associations. The station states that—

If local associations are to meet the requirements of farmers in many parts of the State, they must be organized as marketing rather than forwarding associations. To insure adequate volume of business to justify the expense of a capable manager, office and yard force, adequate equipment, and keeping in touch with the available outlets, the associations should have 500 to 1,000 or more members.

COSTS OF PRODUCTION

Hatcheries in Maryland.—A study of 110 hatcheries by the Maryland station for the period 1936-38 showed the average returns on investment to be 36.9 percent, varying from a loss of 8.4 percent for the 27 least-profitable to a profit of 75.3 percent for the 27 most-profitable hatcheries. The most profitable hatched an average of 112,845 chicks each and had a hatchability of 72.6 percent as compared with an average of 29,894 chicks and a hatchability of 67.2 percent for the least profitable. The average investment per 100 chicks hatched was over $3\frac{1}{2}$ times as large for the least profitable as for the most profitable hatcheries. Hatcheries having an average profit of \$2 or more per 100 chicks expended \$2.91 per 1,000 chicks for fuel, \$7.64 for labor, \$37.80 for eggs, and \$2.11 for selling costs. They hatched 151,704 chicks per hatchery, utilized their capacity 3.1 times, and had a hatchability of 72.6 percent. Those making a profit of less than \$1 per 100 chicks spent \$3.96 per 1,000 chicks for fuel, \$13.76 for labor, \$40.70 for eggs, and \$2.72 for selling costs. They hatched an average of 61,653 chicks per hatchery, utilized their capacity two times, and had a hatchability of 68 percent.

Dairy costs.—A study of the Michigan station covering 499 dairy herds during the years 1932–36 showed that the average cost of producing a pound of butterfat was 32 cents in the 98 low-cost and 53 cents in the 98 high-cost herds. About 25 percent of the difference was due to a 72-pound higher annual production of butterfat per cow and 75 percent resulted from a \$39 per year lower cost per cow, three-fourths of which was due to more efficient feeding and use of labor and a smaller depreciation per cow.

Oranges.—The Florida station found that the costs per acre per year in groves 15 to 17 years of age during the years 1932–33 to 1936–37 ranged from \$86.70 to \$112.81 and the returns from a loss of \$4.41 in 1932–33 to a profit of from \$22.76 to \$203.49 in the other 4 years.

Fiber flax.—In a study of costs and efficiency of flax production in the Willamette Valley the Oregon station concluded that—

in view of the risks involved in flax culture and the small hope of large profit above wages and rent for the land, large increases in flax production are not to be expected until such time as processing costs are lowered.

Potatoes.—On 49 farms in central New Jersey studied by the New Jersey station in cooperation with the Department (B.A.E.) the average yield in 1936 on the one-third of the farms having the highest yields was 266 bushels per acre and the cost 41 cents per bushel as compared with 176 bushels and 56 cents on the one-third with the lowest yields. During the period 1932–36 the average yield on 48 farms in the same section was 228 bushels (44 percent above the State average) and the average cost per bushel of producing and harvesting was 47 cents, of which 24 percent was for fertilizer, 22 for seed, and 15 for labor. In 1912, 37 hours of man labor and 55 hours of horse work were required to produce an acre of potatoes up to harvest while in 1936, on specialized potato farms using general-purpose tractors, only 17.2 hours of man labor, 6.8 hours of tractor use, and 4.1 miles of truck use were required.

FACTORS AFFECTING INCOME

Farm income.—A study of farms in Centre County, Pa., by the Pennsylvania station covering the 7 years ended June 30, 1937, showed the average labor income to be \$150, with a range from —\$531 in 1932 to \$1.019 in 1937. The highest incomes were obtained where crop yields were 10 percent or more above the average, 7,500 pounds of milk were sold per cow, the production index (percentage combined crop and livestock index) was 20 percent above the average, 300 or more days of productive work were put in, and, in the case of dairy farms, where more than 80 percent of the receipts were from livestock products. Farmers with less than \$1,500 gross receipts rarely had a positive labor income while those with receipts of \$4,500 or more had a positive income each year. When gross receipts averaged 12 percent or less of the capital invested there was no labor income in any year, but where the receipts were 24 percent or more of the average capital there was an income each year.

The South Carolina station in a study of 45 farms in Horry County in cooperation with the Department (B.A.E.) found that the average labor income in 1935 ranged from —\$187 on the 12 lowest-income farms

to \$3,111 on the 11 highest. Labor income increased from \$212 where there was less than 20 acres of cultivated land to \$2,243 with 101 acres or more cultivated and from -\$42 where 24 percent or less of the cultivated land was in cash crops to \$1,978 where 45 percent or more was in such crops. Operators' earnings (labor income plus value of family living furnished by the farm) and interest on investments increased from \$520 and 1.8 percent on farms of 20 acres or less to \$1,268 and 11.3 percent on farms of 21 to 60 acres, to \$2,053 and 10.3 percent on farms of 61 to 100 acres, and to \$3,120 and 11.6 percent on farms of 101 acres or more.

A study of records obtained from farms on the limestone hill land of the Eden shale belt of Kentucky by the Kentucky station showed the most important factor affecting labor income to be productive man-labor units with the proportion of land in open pasture next in importance and the receipts-per-animal unit third. The average labor income on farms with all three factors above the average was \$479 and that for the farms with the three factors below the average, \$27.

The Arkansas station found the average labor income on farms studied in the central part of the State to vary from -\$126 for 9 farms with an average of 59 productive man-work units per farm to \$909 for 23 with 796 units per farm. For the farms with a crop index of less than 60 the labor income averaged \$108 as compared with \$267 where the crop index averaged 100 or more.

The Minnesota station determined that the average farm operators' labor earnings in that State were \$1,123 during the period 1928-30, -\$136 in 1931-33, \$2,041 in 1934-37, and \$1,025 in 1938. Size of business, choice of crops, livestock-per-unit area, crop yields, production per cow, feeding and labor efficiency, and control of overhead expenses were the important factors affecting the earnings. In 1938 cash expenses of Minnesota farmers totaled \$125,000,000, of which taxes constituted \$30,000,000, automobile, truck, and tractors \$21,000,000, feed \$18,000,00, interest and wages each \$16,000,000, building and machinery repairs \$13,000,000, and other items \$11,000,000.

Poultry.—The analysis of records obtained by the Michigan station during the years 1931-35 showed that the poultrymen scoring lowest in eggs laid per hen, fall egg production, feeding efficiency, death losses and culling percentage, and labor efficiency had a net loss of 21 cents per hen while those scoring highest had a net return of 86 cents per hen. Feeding efficiency and breed of poultry were important factors affecting pullet costs. Hatching date and mortality of chicks had more influence on profits of the laying flock than on pullet costs, and a slight increase in the net cost of early pullets was more than balanced by the higher egg income.

Milk production.—The Vermont station found that the number of hours of labor and its cost per 100 pounds of milk decreased from 3.1 hours and 58 cents, respectively, for herds with an average production of 4,500 pounds of milk per cow to 2.1 hours and 40 cents for the herds with an average production of 6,500 pounds per cow. The hours and cost decreased from 3.3 hours and 62 cents, respectively, for herds of less than 15 cows to 2.1 hours and 41 cents for herds of 35 or more cows.

Vegetables.—The New Jersey station found that the average labor income in 1937 on 25 specialized vegetable farms in Monmouth County was —\$946. The relatively small size of the business was one of the problems confronting the industry. The farms with sales over \$6,000 (average \$14,791) had an average labor income of \$114 while those with sales less than \$6,000 (average \$2,172) had an average labor income of —\$1,653. Those with yields 27 percent above the average had a labor income of \$553 as compared with —\$2,329 for farms with yields approximately 25 percent below the average.

Cotton.—Average operators' yearly earnings, 1931–35, on farms in the High Plains cotton area of Texas studied by the Texas station in cooperation with the Department (B.A.E.) varied from \$124 in 1932 to \$1,808 in 1933. In general, in the period 1931–32, each additional acre in the farm decreased earnings 54 cents. An increase of 1 percent in the proportion of land in cotton increased earnings \$12.80 and a 1 pound higher yield per acre, \$3.62. Each additional animal unit of produce livestock per 100 acres decreased the earnings \$7.18 but each \$1 increase in the average returns per \$100 worth of feed fed increased the earnings \$1.67. Each additional day of productive labor performed per man, excluding harvest, was associated with an increase of \$3.15 in earnings. These six factors accounted for approximately 63 percent of variations in earnings on the farms. The earnings ranged from —\$487 on farms below the average in all six factors to \$1,099 for those above in all the factors.

Tobacco.—In a study of the management of farms in Pittsylvania County growing flue-cured tobacco, the Virginia station in cooperation with the Department (S.C.S.) found that the cost and returns in the production of tobacco were the most important factors affecting the labor income of the farms as a whole. The farms averaged 142 acres, of which about 25 percent was cropped, and 8.3 acres in tobacco. The most important factor affecting the income from tobacco was quality. Yield per acre was next in importance followed by the operation of a relatively large business effectively as to labor, power equipment, and other capital costs. Total costs averaged about \$100 less and profits \$120 to \$130 more on tobacco acreages of 12½ or more acres than on those of less than 3½ acres, due to the fact that the fields and production were larger, labor could be used more efficiently, grading done better and more economically, and handling charges reduced. Yields of 800 pounds or more of tobacco per acre returned 15 to 18 cents more per hour for labor than those of 500 pounds or less. Farms with 270 or more work units per man for all purposes averaged \$528 higher labor incomes than those with less than 150 units. With total capital less than \$1,500 tenants had higher labor incomes than owner-operators and with less than \$250 croppers fared better than tenants. Under comparable conditions white and colored operators had about the same labor income.

LAND PRICES, TRANSFERS, AND TENURE

Land prices.—A study by the Minnesota station showed that the average price of Minnesota farm land rose from \$12 in 1870 to \$26 in 1900, to \$41 in 1910–11, and reached the peak (\$104) in 1920–21, then declined to \$40 in 1934–35 and \$39 in 1936–37.

Land transfers.—Studies of the number and types of farm-land transfers were made by several stations. Of nearly 10,000 transfers in 1928-33 in 12 counties studied by the Nebraska station, 63.8 percent were voluntary, 16.4 distress transfers, and 19.8 percent gifts. The ratio of assessed to sales value was higher for the voluntary than the distress transfers, indicating that high taxes were not the major cause of the distress transfers. The claims in the case of distress transfers were 67 percent of the price received when sold in the counties having an average land valuation of \$75 per acre and 50 percent in the counties with an average land valuation of less than \$75. The distribution of the distress transfers among the different grades of land was similar to the distribution of grades of land within the counties.

Tenancy.—The Iowa station in cooperation with the Department (R.A.) in a study of landlord-tenant relations in four counties in the southern part of the State found that 70 percent of the leases were crop-share, 10 percent stock-share, and 20 percent cash. Sixty percent of the cash-rented farms were less than 100 acres while more than 50 percent of the stock-share and 40 percent of the crop-share farms were 181 acres or more. Tenants remained the longest time on stock-share farms and the shortest time on crop-share farms. The most conservative use of land was found on the stock-share farms and those where the landlord and tenant were related. The most exploitive use was on cash-rent farms and those where tenant and landlord were not related.

Studies of leases and leasing practices were carried on by the stations in California, Colorado, and a number of other States.

TAXATION AND USE OF TAX FUNDS

Assessments.—A study by the Arkansas station showed that in 1937 the ratio of assessed to estimated value of the properties studied averaged 57 percent for rural properties and 40.5 percent for urban properties. For the rural properties the percentages decreased from 113.4 percent for those with an estimated value of less than \$600 to 68.6 percent for those valued at less than \$5,000 and to 39.2 percent for those valued at \$40,000 or more. Those valued at less than \$5 per acre were assessed at 140.8 percent of the estimated value as compared with 33.4 for those valued at \$70 or more per acre. Farms with 20 percent or less of the land in crops were assessed at 87.7 percent and those with over 80 percent of the land in crops at 43.3 percent. Nonagricultural, unproductive, and low-productivity lands were assessed at approximately 88, 77, and 79 percent, respectively, of their estimated values, lands of moderate or good productivity at approximately 59 percent, and those of high and very high productivity at 48 and 41 percent. While the index of value of farm real estate in the State dropped from 222 in 1920 to 118 in 1931, assessed valuations on 746 rural properties studied changed only 957 times out of a possible 4,476 times. Forty-five of the properties were assessed at the same amount throughout the period 1914-35. In one county only 43 percent of the automobiles were on the tax rolls in 1937. The average assessed valuations for automobiles varied among the counties from \$49.17 to \$132.13 and that for horses and mules from \$13.03 to \$55.37. The ratios of assessed to estimated values for individual cars varied from 4 to 200 percent.

The Rhode Island station in cooperation with the Department (B.A.E.) found that from 1913 to 1937 farm taxes per acre increased

from 53 cents to \$1.57, and per \$100 valuation from \$1.06 to \$1.53. In 1934 the taxes were 49 cents or less per acre on 19 percent of the 227 farms studied, 50 to 99 cents on 24 percent, \$1 to \$1.99 on 24 percent, \$2 to \$2.99 on 15 percent, and \$3 or more on 18 percent. The percentages of uncollected taxes increased from 15 percent in 1928 to 23 percent in 1934, then dropped to 20 percent in 1935.

A study by the Kansas station brought out the fact that in 1936 oil-producing properties in the State paid taxes amounting to \$150 per \$100 of gross income as compared with \$8.04 for farm property.

A study of 512 white-owner and 162 Negro-operated farms by the South Carolina station showed that small farms have relatively large investments, low incomes in proportion to investment, and pay taxes high as to income but about on a par with investments. Those with small investments have relatively small incomes and high taxes while those with large investments have relatively large incomes and low taxes. The farms where expenditures exceeded receipts had less than their proportionate share of the acreage and investments but paid more than their proportion of the taxes while those reporting incomes of \$500 or more had relatively large acreages and investments but paid low taxes in proportion to both investment and income.

Tax delinquency.—The Ohio station, in a study in two counties in the southeastern part of the State, found that of the land delinquent for 4 years or longer 17 percent in one county and 11 percent in the other was satisfactory for agriculture, 6 and 9 percent additional were poorly adapted to agriculture, and 77 and 80 percent were submarginal.

The Arkansas station in a study of the amounts of tax-forfeited land certified to the State in 1929–35 and the disposition of State-owned lands in 1928–37 found that the amount of State-owned land increased from approximately 1,093,000 acres on January 1, 1929, to about 1,448,500 on January 1, 1934. Certificates for lands delinquent on the 1926–30 assessments amounted to over 1,695,000 acres by January 1, 1934. In 1933 over 1,557,000 acres were due for certification but only 21 percent were certified. Redemptions during 1928–37 amounted to over 1,368,500 acres, of which over 48 percent were under special acts in force during the period 1933–35. The sales by the State were approximately 1,001,000 acres. Of 621 tracts in 168 townships listed in 1938 as State-owned only 18 percent had possibilities for homestead use, 53.6 percent being unsatisfactory for homestead or farming purposes and 28.4 percent either redeemed, sold by the State, or in question as to the State's title.

County ownership and management of lands.—A study by the South Dakota station of county management of the lands in 8 northwestern counties of the State showed that 43 percent of the total lands were nontaxable, that 2,000,000 (17 percent) acres were subject to tax-deed action in 1938, and 903,000 acres were under contract for the payment of back taxes. Less than 25 percent of the area in the counties was taxable land on which taxes were paid up. In June 1938 the counties owned nearly 1,260,000 acres of land. Previous sales of such land totaled only about one-tenth of the area being held, and only about 70 percent of the county-owned lands had been leased to farm or ranch operators. The legislature used many of the recommendations in this study in enacting a County Land Administration and Management Act.

Sales taxes.—A Kansas station study showed that had the present State sales-tax law been in effect in 1936, renters would have paid \$23.33 in sales taxes or 82.4 percent of the property tax paid by them, part-owners \$33.85 or 21.5 percent of the property tax, and owners 31.26 or 11.4 percent of their property tax.

Use of tax funds.—The Delaware station as a part of its study of taxation published tables and graphs showing for the period 1924-37 the income of the State from current and extraordinary sources and the current and extraordinary expenditures for the various functions of government.

The Ohio station in cooperation with the Department (B.A.E.) made an analysis of the receipts and expenditures by counties, townships, school districts, and villages during the period 1931-36 in Noble County, representative of the southeastern hill section, and Putnam County, representative of the western section of the State.

CREDIT

Montana farm foreclosures.—A study by the Montana station showed that from 1870 to January 1, 1938, nearly 34,000 farm real-estate mortgages involving more than 11,000,000 acres, \$75,000,000 of loans, and \$25,000,000 additional claims had been foreclosed in the State. The number of foreclosures averaged over 4,000 per year during the period 1921-25, over 1,300 annually 1926-30, and over 465 annually 1931-37. The loans foreclosed averaged about one and one-third times the productivity value of the lands determined by a scientific soil survey and average yields and prices as compared with about two-thirds times for all mortgaged lands. The station states that farm foreclosures can be reduced by basing loans on the productivity value of the lands, by adjusting annual repayments to current income in terms of buying power of products rather than dollars, by effecting a strong credit education program to familiarize both borrowers and lenders with the consequences of the present unwise credit practices, and by incorporating provisions in the mortgage contracts requiring use of improved farm-management and land-utilization practices.

Another study by the Montana station, in the central part of the State, showed that a number of factors had affected farm-mortgage loan foreclosures. Seventy percent of the loans made from 1911-20 and 41 percent of those made from 1911-33 had been foreclosed by 1937. Twenty-one percent of the loans on livestock ranches had been foreclosed with a loss of 5.2 percent of the principal, as compared with 44 percent of the loans on wheat farms with a loss of 14.9 percent. Land productivity and loan experience were closely related, 22 percent of the loans on first-grade farm land having been foreclosed as compared with 58 percent on fourth-grade farm land and 8 percent of those on farms with average wheat yields of 20 bushels per acre as compared with 61 percent on farms with yields of less than 5 bushels. Loan experience was closely associated with size and productivity value of farms. Fifty-nine percent of the loans on wheat farms with less than 200 cultivated acres were foreclosed as compared with 16 percent on the farms with 1,000 or more acres cultivated. Sixty-three percent of the loans on wheat farms with

less than \$1,000 productivity value were foreclosed as compared with 10 percent of those on farms with a productivity value of \$10,000 to \$20,000. Twenty-six percent of the loans at less than \$5 per acre of total acreage, 42 percent of those at \$5 to \$10, and 49 percent of those at over \$20 were foreclosed. Of loans at less than \$10 per cultivated acre, 12 percent were foreclosed as compared with 49 percent where the loan was \$25 or more per cultivated acre.

A study by the Iowa station in the 31 southern counties of the State showed that from 1915-36 the acreage foreclosed during the period was equal to 19.8 percent of the farm lands in the counties and that from 1915 to 1920, inclusive, there were practically no foreclosures. During the period 1921-30 foreclosures were made annually on approximately 1 percent of the land, mostly under junior mortgages, during 1931-33, 1.8 to 3 percent of the land was foreclosed annually, chiefly under first mortgages, and in 1934-36 foreclosures were made on 1 percent or less of the land annually. Forty-two percent of the foreclosures were on loans made by individuals, 27 by insurance companies, 15 by banks, and 16 percent by the Federal land bank, joint stock companies, loan companies, and miscellaneous lenders. By 1939 corporations owned approximately 12 percent of the entire area of the State, the increase in holdings during the last 2 years being equal to 1,800 farms of average size. The increase was due mainly to foreclosures in 1936 and 1937 as a 1-year redemption period is allowed after foreclosure sale.

Farmers' ability to repay loans.—The Illinois station, in a study of 1,055 farms, found that where the net cash income was \$2,000 or over, owners had a debt-repaying capacity of \$1,732, part-owners \$1,992, and tenants \$1,713. With net cash incomes of \$1,000 to \$1,999 the debt repayment capacities were \$166, \$299, and \$461, respectively, while with incomes of less than \$1,000, capital was being used up and further debts were being contracted to amounts of \$607 by owners, \$407 by part-owners, and \$242 by tenants. In the highest-income group the debts of owners averaged about 6 times the yearly capacity to repay, those of part-owners 4 times, and those of tenants 0.4 time. In the middle-income group the debts averaged 38, 14, and 1.4 times the yearly capacity to repay. The station states that—

in mortgage lending, according to this analysis, three plans involving different lengths of time for retiring debts are needed in order to fit a loan to the capacity of the borrower to pay it: Amortization in 10 years or less—for farmers having high capacity to pay and light debts. Amortization in 20 to 25 years—for farmers having high capacity to pay and heavy debts. Amortization in 35 to 40 years—for farmers having low or medium capacity to pay and heavy debts.

MISCELLANEOUS

Cost and utilization of power.—An analysis of over 1,700 records of cooperating farmers in 1936 and 1937 by the Iowa station showed no consistent difference in the combined cost for labor, horses, tractors, and machinery between general-purpose tractor and horse-operated farms, but the costs on such farms were lower than on standard-tractor farms. The costs on the farms that had used general-purpose tractors for 4 years or more were lower than on horse-operated farms. The horse farms were smallest and the general-purpose tractor farms the largest in size. On the general-purpose tractor farms 4.9 hours

of man labor and 27.5 drawbar horsepower-hours were used per acre of corn up to harvest as compared with 9.4 hours of man labor and 30.9 drawbar horsepower-hours on the horse-operated farms. Tractors mounted on pneumatic tires used 22 percent less fuel and had an estimated life one-third longer than those with steel wheels but these economies were offset by the cost of the tires.

Seasonal labor requirements.—The California station found that nearly 22,460,000 man-days of seasonal labor were required in the State in 1935-36. The monthly requirements varied from approximately 948,300 to 1,451,800 man-days for the months November to April, inclusive, to from 2,071,250 to 2,300,800 man-days in May, June, and July and to from 2,762,700 to 3,100,400 man-days in August, September, and October. The number of workers needed varied from nearly 48,200 in March to 144,700 in September. The average number of man-days of seasonal labor per 1,000 acres of different crops was: Carrots 21,117, cotton 7,302, hops 37,100, lettuce 8,389, pears 7,896, peas 9,404, prunes 4,130, sugar beets 5,605, tomatoes 9,724, and walnuts 1,067. Lemons and oranges required 71 man-days per 1,000 boxes and onions 105 man-days per ton.

Value of farm perquisites.—Records secured by the Michigan station for the years 1929-37 showed that the annual value of farm products used by the farm household averaged \$295 and the allowance for house rent \$200.

Farm electrification.—The operators of 677 electrified farms studied by the New York (Cornell) station estimated that the electric service from central stations increased the farm values about 17 percent, or an average of \$1,100 per farm. Forty-eight farm and twenty-eight household uses for electricity were found on the farms. Only one-fifth of the farms had electric refrigerators. Of the grade A dairy farms one-half had electric clippers and milk coolers and one-third electric milking machines.

RURAL SOCIOLOGY

The following are some of the results of studies in rural sociology reported by experiment stations in 1939.

POPULATION STUDIES

Population trends and adjustments in Arkansas.—The most significant population difference between rural and urban areas as reported by the Arkansas station is in the number of dependents. Rural areas have a lower proportion of people of working age and a higher proportion of children. Rural sections have, therefore, a heavier burden, relative to urban communities, in caring for dependents and in the education of the children, which is doubly difficult because of their lower rates of per capita wealth and income.

Birth rates in the rural districts are high in relation to the ability of the area to support population. In several mountain counties of Arkansas the population would double in a single generation except for migration. Emigration is necessary to relieve population pressure but also results in the loss of people at their most productive age.

In 1930 there were 12.2 acres of cropland per farm person in the United States at large, as compared with only 6.1 acres in Arkansas.

This pressure of population was not equally distributed over the State but was abnormally high in the mountain areas. In Arkansas County there were 11.9 acres of cropland per farm person, as compared with only 3.2 in Garland County and 4.0 in Newton. Income per acre of cropland was slightly higher than the national average, but income per farm person was lower because of the higher man-land ratio. This overcrowding is associated with the high birth rates in these areas and will tend to become more severe unless migration channels are opened again.

Significance of population changes in Colorado.—A survey by the Colorado station demonstrated the high mobility of an important section of Colorado's farm population. High mobility raises problems of adjustment for individuals, families, communities, and units of government. The rapid transfer of population in large numbers from one section of the State to another is creating problems for schools, public welfare agencies, and other social institutions and services. For example, one school district in a western-slope county reports that its enrollment jumped from 175 to 517 while its valuation for tax purposes was cut in half. An official of the same county claims that a high proportion of the newcomers will become permanent relief clients because they have no resources and the county has no real place for them. Areas of depopulation and farm abandonment also have serious problems, according to the reports of cooperators in this survey, in terms of neglected land, diminished tax base, and changed community patterns. Knowledge of the nature and location of farm population changes should be an aid to the solution of some of these problems.

Farm population study.—In an analysis of mobility of farm population in the Great Plains area by the Colorado station there appeared to be no significant difference with respect to the movers and nonmovers from the standpoint of age of head of family, education of the head, percentage of males in employable ages, and age distribution. In two cases out of three the farmers who continued to operate in Baca County had larger farms on the average than their less stable neighbors. It appears therefore that from the point of view of its human resources the farm area of Baca County has certainly not been weakened qualitatively (as measured by the indices used) as a result of the very large migration of people from its farms during the drought years. Rather, there is some indication that the county is basically in a better position with respect to the characteristics of the people on the land than it was before the drought.

Farm population movement.—A study by the North Dakota station of the estimated farm population movement in North Dakota during 1936 and 1937 indicated that 75,000 farm persons moved during these 2 years. The number of migrants was equal to one-fifth of the entire farm population of the State. One-half of these people continued their residence in the same county and about two-thirds remained in the State. One-third of the total migrants went to other States.

An analysis of certain drought indices and the farm population movement indicated that drought and resulting crop failure were influential factors in movement from farms but that there was no

significant relationship between drought criteria and movement of people to farms.

California.—A study by the California station discloses the fact that increased migration in recent years, especially among agricultural labor, has necessitated more detailed and reliable information on agricultural population of the State. The method of analysis employed serves as a model for the study of agricultural populations in connection with farm income and as a basis for a number of recommendations of the Census Bureau for desirable changes to be incorporated in the 1940 census.

Marginal population.—A study by the Virginia station revealed that some 100,000 white and 65,000 Negro families, or approximately half of the rural population of the State, may be classed as marginal from the standpoint of income (\$600 gross farm income or less), education (fifth grade or less), and living standards.

A check of 194,000 names of white males on the tax rolls of 37 counties showed 42 percent as assessed with real estate and personal property taxes of only \$2.50, while 58 percent of 42,321 Negroes were assessed with this amount.

The marginal-standard families average approximately one-third more children than families of higher standards though many strains have more than double as many. A check of 367 completed family strains which have been marginal for generations showed an average of 7.3 living children as compared to less than 2 per family in a parallel group of families of higher standards. One predominantly marginal strain whose record was traced for 150 years has nearly 3,000 individuals in the State now, descendants of male lines only, as compared to 170 descendants of George Washington's grandfather now living in Virginia and 890 in the whole country, both male and female lines considered. Study of a number of other family strains show a similar trend.

The data indicate that the marginal group climbs up the socioeconomic ladder from generation to generation to a much smaller extent than is commonly thought to be the case. This group is, therefore, gradually constituting a larger and larger proportion of the State's rural people.

A little over half of the counties show an increase in the percentage of families in the tenant status in 1935 as compared to 1910, or total increase of 27.5 percent. Of the 74 counties with a substantial Negro population 67 showed a decline in Negro land ownership in the last 25 years. Altogether Negro land ownership decreased 252,000 acres in this period.

Social history.—The South Dakota station, cooperating with the Division of Social Research, Works Progress Administration, in a bulletin on Basic Trends of Social Change in South Dakota concluded that it is entirely possible that South Dakota's peak population was reached in 1930. Between 1930 and 1935 a decline was registered and sample studies since then have indicated a similar downturn. The population is definitely taking on the earmarks of a typical older State. It is recommended that considerable attention be given to the problems a stationary population will create. A declining population does not make necessary a decadent future.

Although the mobility of the farm population during recent years has been a matter of public concern, this study reveals that the movement of farmers out of South Dakota has passed its peak. It also indicates that the birth rate for 1938 is slightly higher and the death rate slightly lower than for 1937.

Drought-period migration.—A study by the Montana station (Bul. 371) revealed that drought-period migration is not unusual but conforms to ordinary mobility patterns. The only outstanding exception is that the movement, under drought conditions, affects more people.

Among the more usual mobility aspects that also characterize drought-period migration are the following: (1) Short-distance mobility is more frequent than long-distance; (2) an exodus from an area is always accompanied by a countermovement of population into the same area; (3) older families and population are less migratory than younger families and population; (4) proportionately more males than females enter the rural areas; and (5) long-distance migrants more frequently tend to go to urban than to rural areas, and more often enter urban and industrial occupations than rural and agricultural occupations.

The study shows, further, that drought-period mobility is only a more intensified form of previous mobility, and that the climatically more favorable sections in the State, despite the fact that they have been receiving migrants from the climatically less favorable sections, also have a heavy exodus of population. The net gain in population in the favorable sections is not nearly as pronounced as the entrance of new population would indicate.

STANDARDS OF LIVING

Levels of living in industrial farm and part-time farm families.—The Mississippi station, in a comparison of the socioeconomic status of farm-reared women employed in cotton mills and garment plants with farm-reared women engaged in farming, found that with high birth rates, back-to-farm movements, and low farm incomes in poor-soil sections, there has been a banking up of man power on the farm with lowered living standards. The expansion of industry, either in the form of full-time or part-time farming, seems to offer one solution to this situation. Yet from the viewpoint of family welfare is this to be recommended? Will industrialization bring about better living conditions? The families were selected so that they were as much alike as possible. All were normal families in which man and wife had been married at least 1 year, all keeping house, and the wives farm-reared and ranging in age from 17 to 35 years. Analyses of data from these families showed the part-time farm group to be on the whole better off than the other groups. They had an advantage over the farm group in a larger cash income and over the industrial group in a generous supply of home-produced foods, largely composed of protective foods. They participated more in social organizations. Relatively few showed a decrease in net worth during the schedule year. This was especially true of families in which the husband farmed full time and his wife was industrially employed. This study points to the need of industries being dispersed throughout poor agricultural areas, industries which might well be combined with farming. A combination of farming and industry seems to make for higher living standards.

RURAL WELFARE

Relief.—The Iowa station reported that 1 in 10 families in the counties surveyed was on relief in 1936, exclusive of Works Progress Administration employment. Relief is not entirely a depression phenomenon in Iowa. It increased steadily from 1920 to 1932, then rose more sharply in response to depressed conditions in agriculture and industry.

The three major developments in the relief situation growing out of the emergency of the past 5 years are: (1) The early break-down of local voluntary relief programs due to lack of local funds; (2) the multiplication of Federal agencies; (3) significant changes in emphasis of each of the three major programs: (a) Gradual decrease in relief to the able-bodied unemployed as business improves; (b) marked increase in the relative number of unemployable families receiving assistance—since there are no employable persons in these families, public assistance must continue to be a major problem for them; (c) the increase in old-age assistance.

According to this report relief will remain a major problem in Iowa for at least a generation, and can be overcome only by the operation of long-time economic and social changes. It will require not only increased care of the aged needy but also the combined efforts of local, State, and national agencies to educate adults, to guide youth, and to see that youth is employed so that it will not further increase unemployment and relief. A comprehensive approach to a solution of the broad problem of relief is represented by the ideas inherent in the Social Security Act.

Unemployment relief, not counting W. P. A. cases, decreased nearly one-third from October 1936 to October 1937; the number of county-care cases did not change materially; persons receiving old-age assistance increased approximately 40 percent. As a result the total number of families receiving assistance from these three agencies was slightly larger in October 1937 than in October 1936. Further large increases are not expected, and there is some tendency for the total relief load to fluctuate narrowly around the present level.

From a study of relief families in Ottawa County, the Oklahoma station concluded that the rapid development of lead and zinc mining during the World War and post-war boom led to the excessive population growth and the deplorable relief situation in that county. Approximately one-half the population of the county, as reported in the 1930 census, was receiving relief in December 1934. Sixty-four percent of the persons residing in the open country, 60 percent of those in villages, 47 percent of the town population, and 35 percent of the city residents were depending upon the Emergency Relief Administration for a major portion of their living.

Of the 1,511 relief households surveyed, one-fourth had 6 or more persons, one-half had from 3 to 5 persons, and the remaining one-fourth contained 1 or 2 persons. All households averaged 4.2 persons, the rural having 4.5 persons as compared with 3.8 persons in urban households.

Of the total number of families, 73 percent were classed in the normal-family type, consisting of a husband and wife with or without children. Broken families, in which one or both parents were missing,

accounted for 16 percent. The nonfamily type, or single persons, comprised 11 percent of the cases. One-third of the households reported additional members, indicating the necessity of "doubling" families as a result of economic distress.

The net fertility of married women between the ages of 14 and 45 years as indicated by these data, showed an irregularly declining trend during the 15-year period ended in 1934. Rural communities had consistently higher net fertility ratios than urban centers. An increasing net fertility ratio was definitely not a concomitant of widespread relief in this county.

Of heads of the 1,511 relief households, 27 percent were unskilled laborers many of whom had mining experience, 21 percent farm tenants as compared with 11 percent who reported farm ownership, 12 percent miners, 6 percent farm laborers, and 11 percent reported "no usual occupation," while the remaining 12 percent were classed in "all other occupations."

The low educational status of heads of families is considered responsible for the apparently weak socioeconomic structure of relief families. One of every eight heads under 64 years of age claimed to be either partly or totally incapacitated by disease or physical disability.

Of the total relief population studied, 53 percent were under 25 years of age two-thirds of whom resided in rural communities. Over one-fourth of the males and nearly one-fifth of the females between the ages of 16 and 24 years had not reached the eighth grade in school. Less than one-third of the persons in this age group had completed the eighth grade.

Ownership of home or farm was reported by 24 percent of the families under study. The average assessed value of the real properties reported was only \$314. The average indebtedness of all households reporting debts was \$159. Mortgages on the home or farm, chattel loans, and obligations incurred for food ranked as the most important debts.

An analysis of the history and amount of relief advances shows discrimination had been practiced against large-size families with regard to the length of time families were advanced relief and in the amount of advances.

In the conclusions reached as a result of this study, the permanency of subsidy from public sources is regarded as inevitable. However, a more intensive use of agricultural resources and the strengthening of social organization among the groups at the lower economic levels appear to be steps whereby public agencies could effect material reductions in relief costs.

RURAL-URBAN RELATIONS

Trade centers.—In a study by the Minnesota station it was found that in Minnesota acceleration of the growth of large trade centers and a relative decline of the smaller centers resulted from the effect of the depression and the post-depression. While the greatest decline of trade centers during the depression occurred in the northern portion of the State, it is now showing the greatest recovery. Small trade centers remote from a large center had a better chance to grow in terms of the number of business units than small centers adjacent to a large center.

The Washington station found that the number of people living in trade centers with less than 2,500 population has increased during each decade, but the percentage of the total population of the State living in them declined from 22.1 percent in 1900 to 13.3 percent in 1930. At the same time the proportion of the total population living in cities has increased. The service population in trade centers with less than 2,500 population apparently does not hold the prominent place it did in the horse-and-buggy age. Fewer people were living in hamlets in 1930 than in 1900 in spite of a 202-percent increase in the population of the State. During the decade 1920-29 hamlets increased markedly in population and villages with 250 to 999 population gained somewhat, whereas towns with 1,000 to 2,499 population lost approximately 6,500 persons.

There were 826 trade centers in the State in 1900. The climax was reached in 1910 when there were 1,160. By 1935 there were only 973. During the twentieth century population has increased more than 200 percent, yet the number of trade centers increased only 15 percent. If trading points with no population are eliminated it will be found that the number of places with population grew from 578 in 1900 to 704 in 1920, an increase of 21.8 percent, and has remained approximately at the 1920 level.

During the period 1900-1935 a relatively high proportion of declining trade centers were in the eastern part of the State where population has declined consistently. A majority of declining permanent trade centers with less than five business units, however, were located in the metropolitan region bordering Puget Sound.

During this period, 840 trade centers appeared and 693 disappeared. The greatest number (482) appeared between 1900 and 1910; the greatest number (274) disappeared between 1910 and 1920, although 114 disappeared during the 5-year interval 1930-34. With the passing of time the relation between appearance and disappearance has changed. During the first decade of the century 3 trade centers appeared for each one that disappeared. During the depression years more than 2 disappeared to every one that appeared. Railroad-town building of the first decade of this century and previously was scaled to the horse-and-wagon stage in farm transportation. The surfaced highway and the automobile brought about a radical change in the town-country trade pattern. No longer was a crossroads store needed every 5 to 10 miles. Since 1900, 461 successful trade centers have appeared, that is, 461 trade centers have succeeded in surviving until 1935. Three-fourths of them still have less than 5 business units. Two, or only five-tenths of one percent, have exceeded 100 business units.

The decline of the fourth-class post office was no doubt a factor in the failure of the hamlet, for the rural mail route made the regular visit of the farm family to the hamlet unnecessary. The parcel-post system added to rural routes brought the mail-order house into competition with the farm trade center.

The growth of newspaper and radio advertising, the increased circulation of papers, and use of radios in rural homes, combined with the greater freedom of movement have contributed to the drawing power of the metropolis and lessened the dependence of the farm family upon nearby trade centers.

SOCIAL GROUPS

Rural school services.—The Arkansas station found that in the 115 open-country districts, containing 80 percent of the farm population of Washington County, the enrollment in high school was only 11 percent of the potential enrollment. In the 14 districts containing a village or town and having a 4-year high school the enrollment was more than 60 percent. A comparison of central and open-country districts reveals some of the factors related to the consistent disparity between school enrollment in villages and farm communities.

Central districts with superior resources have fewer children, in proportion to supporting population, for which to provide schools. About 90 percent of the population of central districts is concentrated in the village or town in which the high school is located. The average number of enumerates in central districts is 464 and in open-country districts 59. Farm children reside at an average distance of 8 miles from the high school, and some as much as 20 miles. While most central districts provide school transportation, the use of school buses commonly extends to less than 10 percent of open-country districts.

Socioeconomic educational studies.—The South Carolina station, working in cooperation with the General Education Board, has attempted to relate the general economic and social background in a strictly rural community to the present and probable future development of the community. These studies reveal a distressing situation which is perpetuated by its own environment. The rural schools are preparing pupils for college when comparatively few ever get to college. The children of tenant farmers drop out of school earlier than the children of owner farmers, but the children of owners leave the area in far greater proportion than the children of tenants. There was not to be found in the entire study area one person who attended college and returned to the community to devote his full time to farming. Since the State assumes responsibility for operating the schools 8 months of the year while the district is responsible for the school plant, the work in many schools is carried on under very unsatisfactory conditions which the districts have not the taxable wealth to correct.

Community studies.—The South Carolina station reported a very low cash income for the average family of the rural-school area selected for study. Almost all of the cash income, which does not average more than \$325 per family annually, is derived from cotton. Production of corn, meat, milk, and vegetables, most of which are consumed on the farm, is low. Eighty percent of all the farm families spend less than \$100 annually for either clothes or food. There is only \$85 of taxable property back of each person, and only \$297 back of each child enrolled in school. In the amount of taxes actually collected on all of the assessable property, there is allowed for school purposes the small sum of \$4.54 per pupil. Fifty-six percent of the entire population is below 21 years of age. Of the total youth population, 29.4 percent are children under 6 years of age. Of every 10 youth in the area, 6 are from tenant homes and of all children under 6 years of age, 73 percent are from tenant homes. The elementary pupils from tenant homes make poorer progress in school than the pupils from owner homes. Sixty-eight percent of all the elementary

enrollment is below the fifth grade, 53 percent from owner, and 77 percent from tenant homes.

More youth from owner homes leave the area for employment than youth from tenant homes, the ratio being 3 to 1. More children are produced by the tenant family. According to standard achievement test grade scores, the reading ability of the rural seventh-grade pupils was 3 to 4 years lower than that of the seventh-grade pupils in nonrural schools.

The teachers of these rural elementary schools are a product of the community in which the schools are located. Of 36 teachers, 27 attended the elementary schools of the study area and 15 attended the same elementary schools in which they now teach. The median of college training received is 1.8 years.

The schools of the area are top-heavy with lay management and are in need of educational leadership and planning. There are almost as many school trustees as teachers. The trustees select the teachers, control the schools, disburse all district funds, and in too many ways influence the teaching program. They do not keep a record of either district finance or pupil progress. The small district school system is the insurmountable obstacle in the way of the school progress of these rural children. The small school is not only inefficient but it is also expensive.

Rural households.—From a study of 2,925 households, or about 80 percent of all households in the open-country area of Genesee County, the New York (Cornell) station found that one-half are composed of husband, wife, and children, and one-sixth include only husband and wife. One in eight consists of a married couple, children, and other persons, and 1 in 10 is a broken-family household of 1 parent with children and other persons. In addition, in 1 of each 30 households no marital ties exist between the household members, and 1 in 40 consists of only an unmarried man or woman.

The households vary in size from 1 to 14 persons. Two-person units are the most common, but no unit of a given size includes more than 26 percent of all the households. The household size in which the largest percentage of the individuals reside is the 5-person unit. But this unit includes only 17.3 percent of all individuals, and each of the households of 2 to 8 persons includes as many as 10 percent of all the individuals, so that considerable concentration in any household of a given size does not exist.

Eighty-one percent of the 2-person households are composed of married couples; 80 to 98 percent of those comprising from 3 to 9 individuals are of the husband-wife-children or husband-wife-children-other-person types. Related or nonrelated persons reside in 1 of each 6, and 1 of each 20 households, respectively; one-fourth of all the individuals live in households that contain relatives, nonrelatives, or both. Of all the individuals in the households, 90 percent are resident-family members; 7 percent, relatives; 2 percent, nonrelatives; and 1 percent maintain their own separate domiciles.

The average size of the households is 4 persons. Farm households average 4.1, and nonfarm 3.9 persons, but these averages mean little when the differences in type and number of persons is considered. The average size of the different types ranges from 1 to 11 persons, indicating little uniformity in household size.

In more than one-half of the husband-wife-only households, the age of the female head is 55 years or more, and 72 percent are 45 years of age or more, indicating that most two-person households are completed families, the children having grown up and left home.

Farm laborers.—A study of farm laborers by the Arizona station disclosed that practically all of Arizona's laborers on irrigated farms were of agricultural background. More than one-half of the heads of laborers' households were of Mexican origin born in the State of Sonora or in southern Arizona. Another third were from the Cotton Belt, from other States, or native to Arizona, and the remainder were Yaqui Indians, Negroes, or orientals.

Normal households composed of a man and woman or man, woman, and children prevailed more strongly among farm laborers than among farm operators or among other occupational groups dwelling in irrigated areas. By far the greater part of all farm-laborers' households made no change in residence during a sample period of 15 months. Similarly a very large part of the heads of laborers' households made no change in occupation. More living children were reported by Mexican mothers of completed families than by mothers in other racial and nativity groups. Since so great a proportion of Mexicans were laborers, it was apparent that older Mexican laborers would readily be replaced by younger Mexicans for many years to come. Since almost 70 percent of the heads of households who were farm laborers were under 45 years of age as compared with 50 percent of the tenants and 36 percent of the farm owners and managers, it was evident that farm laborers as a class were in the most vigorous years as compared with other agricultural classes. Arizona's farm-labor population was found to have the characteristics that make for a reasonable degree of success in their occupation. In cultural background, in primary forms of social organization, in degree of geographic and occupational stability, and in bodily vigor, the farm-laborer population was found suitable to the needs of agriculture in irrigated areas, particularly those needs or requirements that call for common labor—experienced and willing but not necessarily skilled.

Clustered residences as compared with solitary residence were apparently preferred by many laborers' households probably for reasons of sociability as much as any other. Operators apparently also favored clustered residence as they often grouped their laborers' houses, sometimes in the open fields, and sometimes by a road or irrigation canal.

Arizona's resident farm-labor supply was found to be numerically adequate for the hired-labor requirements of the irrigated farms of the State during the seasons from January through April and from May through August 1937. Many farm laborers were without steady employment during the January–April season. January requirements were sufficient to regularly employ about three-fourths of the resident laborers, leaving out of consideration the out-of-State laborers who came to pick cotton. By March the requirements had fallen to a low mark for the year, only three of every five resident laborers being regularly needed as hired laborers. During the middle of the May–August season farm laborers were practically all needed to meet farm requirements, but later there was a falling off in demand so that more than one-fourth of them were not needed during August.

From September through December all resident laborers on farms and in rural towns were required and many more were drawn from other sources. Numbers of workers increased through October into November as the cotton-picking season advanced, until a peak supply of 45,600 hired laborers was reached, 20,000 of whom had come from outside the State.

Rural interests.—From a study of 35 local weekly newspapers, the Michigan station concluded that, although residents in rural communities have a great variety of interests pertaining to their community, those relating to personal affairs and personal relationships are the dominant ones. Considerably more space was devoted to neighborhood and personal news than to any other topic pertaining to the community. Community leaders or others interested in the development of objectives in community life, such as efficient government, good farming, or adult education, may expect a more satisfactory response from the community if the personal aspect of the activities associated with such values is emphasized.

Analysis of editorials shows that the rural weekly papers contributed to the development of interests pertaining to local community affairs by directing the attention of readers to matters that might otherwise be overlooked, or by interpreting events relating to the community. In the editorials the more abstract values were considered and in this respect the local paper performed a role similar to that of the church, the school, or public forum in the development of community interests. Although printed for a different purpose, it is possible that some advertising contributed also to the development of constructive interests among rural people. Finally, the study shows that the weekly newspaper is a service agency as well as a commercial enterprise and, therefore, activities on the part of people in the community to make a good newspaper are mutually beneficial.

Suburbanization.—The Connecticut (Storrs) station, in a study of Wilton, a rural town near metropolitan New York, found that the population increased from 1,284 inhabitants in 1920 to 2,133 in 1930; and it is estimated that by 1937 it had further increased to 2,866. The greater part of the incoming stream of migration consisted of householders in the professional and business occupations. A considerable number of retired persons moved to the town as did a smaller proportion of persons in the industrial and farming occupations. A total of 86.9 percent of the households surveyed were permanent residents and 13.1 percent seasonal. Most of the newcomers come from cities, particularly New York City. Some of the reasons given for moving to Wilton were: Advantages offered to children by the local school and open country; lower taxes; and accessibility of Wilton to cities, combined with a rural New England setting. Nearly one-half of the gainfully employed householders of Wilton are commuters, and as many as 3 out of 10 commute to work in New York City.

Slightly less than half of the households in town do a little farming. Aside from a few very good fruit farms, however, most of the farming tends to be recreational or hobby. Only 3.6 percent of the householders operate farms of large enough size to be called commercial farms. Even among the commercial farms, 3 out of 10 are operated by householders whose principal occupation is not farming

but who are business and professional people. Thus it appears that farming as a livelihood in this town is becoming more valuable for residential and recreational purposes than for commercial agriculture. In fact, it may be said that some of the characteristics which lead to its decline in importance for commercial agriculture (hills, stones, lakes, streams) have accentuated its value as a residential and recreational area.

The type of home sought in Wilton by urban migrants is one with fairly spacious grounds, usually large enough to enable them to carry on a little hobby farming or gardening. The median householder has 3.5 acres of land and the average size of the holdings is 14 acres.

Another prominent characteristic of the community is the large proportion of householders with considerably more than an ordinary amount of formal education. As many as 21 Wilton householders are listed in *Who's Who in America*. Many of the more highly educated householders are recent arrivals and commuters. The suburban movement has left its impress upon the social organizations of the community. This is especially noticeable in the existence of such organizations as the Choral Club, which presents a light opera each year, the Play Shop, the Garden Club, and others. A modern town hall has recently been erected which is adequately equipped to serve as an efficient community center. Some striking facts were brought to light concerning affiliation with religious organizations. Nearly all of the householders indicated a religious preference of some sort but less than half of them actually belonged to a church; and even when they held a church membership, they held it in nonlocal churches five times out of eight. In general, religious preference was overwhelmingly Protestant, with the Episcopal Church gaining the adherence of many of the recent arrivals, and the Congregational sect attracting older or long-term residents. Only a very small proportion of the recent newcomers affiliate with the local churches. This proportion tends to increase somewhat with longer periods of residence.

4-H Club work.—The Illinois station found that 4-H Club training had a direct effect upon capability as measured by the achievement test, but the indirect effect of this training through such avenues as adaptability and attitudes toward farm life was not so strong as had been expected. The increase in capability resulting from 4-H Club work was especially noticeable among the boys who had taken no agriculture in high school but who had carried on beef, sheep, or corn projects, and among the girls who had not had home economics in high school. Interest in the possibilities of farming and farm life was associated with achievement, and farm-boy members made higher scores on this attitude than farm-boy nonmembers.

Members of 4-H Clubs, both boys and girls, had in general a more appreciative attitude toward farm life than nonmembers. This difference may have been partly due to club training, but it resulted also in part from the fact that young people with the more appreciative attitude tended to join 4-H Clubs. Boy members had in general a greater interest in the possibilities offered by farming than nonmembers. Work in a 4-H Club apparently had very little influence on the tendency of boy members to dominate or to be dominated in the various social situations encountered by them. Members of 4-H Clubs, both boys and girls, gave indications of having greater social-

mindfulness and more leadership ability than nonmembers. It was not possible to determine, however, whether the difference was due to 4-H Club training or to selectivity.

STATISTICS OF THE EXPERIMENT STATIONS

In tables 1 to 9 there have been assembled data of a statistical character concerning the personnel, publications, mailing lists, income, expenditures, and additions to equipment of the experiment stations for the fiscal year ended June 30, 1939; also disbursements from the United States Treasury to the States, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Federal-grant acts.

PERSONNEL AND PUBLICATIONS (TABLE 1)

The number of research workers on the station staffs in 1939 was 4,454, an increase of 235 over 1938. The increase consisted of 158 full-time research workers and 77 whose time was divided between research and resident teaching, research and extension, or research and both resident teaching and extension work. Of the 4,454 technical workers in 1939, 2,244 gave their full time to research while the time of the other 2,210 was devoted partly to research and partly to resident teaching or extension work or both.

The publications of the experiment stations in 1939 included 883 bulletins and circulars in the regular series, 2,241 articles in scientific journals, and 662 miscellaneous publications. The comparable figures for 1938 were 743, 2,510, and 571, respectively.

INCOME (TABLE 2)

The total income available to the stations for 1939 was \$20,622,758.61 as compared with \$19,848,068.43 in 1938. The 1939 income consisted of \$6,541,250 from the 4 Federal-grant funds and \$14,081,508.61 of supplementary funds, including State appropriations, special endowments and fellowships, fees, sales, miscellaneous, and the unexpended balances from the preceding year.

Federal grants.—Federal grants to the States, Territories, and Puerto Rico for agricultural research in 1939 amounted to \$6,541,250 as compared with \$6,232,500 in 1938. The increase of \$308,750 consisted of \$1,250 to Alaska, \$5,000 to Hawaii, and \$2,500 to Puerto Rico under the Purnell Act, and \$300,000 under the Bankhead-Jones Act, which, in accordance with the act, was allotted to the States, Territories, and Puerto Rico on the basis of rural population.

Supplementary funds.—The amount of funds made available by the States in 1939 was \$14,081,508.61 as compared with \$13,615,568.43 in 1938, an increase of \$465,940.18. The income of the stations from sources other than Federal-grant funds was approximately \$2.15 for each \$1 of income from the Federal grants. State appropriations in 1939 totaled \$9,274,043.21 as compared with \$9,079,796.69 in 1938, an increase of \$194,246.52. This was approximately \$1.42 for each \$1 received from the Federal grants. Funds from special endowments and fellowships, fees, sales, miscellaneous sources, and balances from the previous year amounted to \$4,807,465.40 in 1939 as compared with \$4,535,771.74 in 1938.

EXPENDITURES (TABLES 3 TO 7)

Classified expenditures are shown for each station under the Hatch Act in table 3, the Adams Act in table 4, the Purnell Act in table 5, the Bankhead-Jones Act in table 6, and for supplementary funds received from within the States in table 7.

The expenditures of Federal-grant funds totaled \$6,540,648.63. Only \$601.37 of the appropriations was not expended.

The expenditures from supplementary funds totaled \$12,396,983.89 and amounted to approximately \$1.90 for each \$1 expended from the Federal-grant funds.

ADDITIONS TO EQUIPMENT (TABLE 8)

Further improvements in physical plant and equipment facilities of the stations were effected in 1939 with funds derived from both public and private sources. The total of expenditures was \$1,502,-647.17, of which \$395,013.01 was spent for buildings, \$61,088.47 for library, \$392,223.99 for apparatus, \$404,510.66 for farm implements, and \$249,811.04 for livestock.

At the New Hampshire station Pette Hall was completed and in use during the year by the departments of agricultural engineering, home economics, and military science. Space for station workers in entomology, horticulture, botany, soils and crops, and poultry husbandry was being provided in two new wings to Nesmith Hall. A new home economics building was under construction at the University of Arkansas and an addition to Atwater Laboratory for research on animal diseases and genetics was nearing completion at the Connecticut (Storrs) station.

Doubling space formerly available for work in dairy husbandry at the Missouri station, Eckles Hall was completed during the year at a cost of about \$117,000. An addition to the veterinary clinic building at Michigan State College, trebling former accommodations, was under contract at a cost of \$133,000. A new wing to the biochemistry building, for nutrition research, especially by graduate students, was in progress of construction at the University of Wisconsin. Of the \$250,000 estimated cost, 55 percent was being supplied by the Wisconsin Alumni Research Foundation and the remainder by the Public Works Administration. Much-needed facilities for research in agronomy and botany were being provided at the Kansas station through the construction of an experimental greenhouse and headhouse. The Oklahoma station completed a third unit of the station greenhouse for work in the plant science fields and entomology, and built a new barn to house the research project on anaplasmosis. The new poultry plant at Pennsylvania State College was dedicated October 27. It contains an experimental unit, an instruction unit, and a central service building with laboratories, feed storage, and refrigeration facilities. The original poultry house at the North Dakota station was modernized with the aid of the Works Progress Administration.

As in other years, the stations received substantial endowments for general and specific research undertakings from individuals and organizations. The Wisconsin station will conduct research on dairy-cattle problems under a grant of \$11,200 from the du Pont Co., and

will have the income of a portion of the estate of Mrs. Gurine Gjermundsen for the establishment of fellowships devoted to the solution of practical problems confronting the Wisconsin farmer in his daily life. A grant of \$49,000 by the General Education Board was made to the Virginia Polytechnic Institute for the development of teaching and research in agricultural economics and rural sociology. The funds are available over a 2-year period and are being used for staff increases in the fields of marketing and farm finance and for library additions in these fields. The Vermont station was the beneficiary of a grant of \$1,000 a year for 2 years from the Sheffield Farms Company for a fellowship in dairy research. The Montana station's program of wool research has been aided through a substantial donation of funds for the purchase of laboratory equipment.

Land acquisitions (not included in table 8) which will facilitate the research work of the stations were the purchase of a new horticultural farm of 160 acres for both experimental and teaching work at the University of Missouri, and the conveyance under an act of Congress of a tract of 37 acres in the Tongass National Forest to the University of Alaska as an experimental fur farm. Typical of the transfers of lands, acquired by the Federal Government under the various purchase programs, to the stations for furthering their research projects is the long-term lease to the Illinois station of some 5,000 or 6,000 acres of the Dixon Springs land utilization project in Pope County. This tract is to be used for research and demonstration work in pasture and livestock farming. Gifts of land totaling 225 acres in Greene County were made to the Ohio station by Hugh T. Birch of Yellow Springs as a memorial to the late Dr. Edward Orton, the land to be used for reforestation and recreation. A new State forest of 900 acres, established in Lorain County as a gift of Judge Guy B. Findley of Elyria, will be used by the Ohio station for experiments in planting and management. The college and agricultural experiment station of the University of Arkansas was given a 100-acre tract of rich delta land near Clarkedale by a group of Crittenden County farmers. The land will be devoted to the breeding of cotton and corn and to experimental work on legumes, small grains, and insect control.

DISBURSEMENTS OF FEDERAL-GRANT FUNDS (TABLE 9)

Table 9 shows the disbursements from the United States Treasury to June 30, 1939, to each State, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Hatch, Adams, Purnell, Bankhead-Jones, and supplementary acts.

TABLE 1.—Organization, personnel, publications, and mailing lists of the experiment stations for the year ended June 30, 1939

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications				Names on mailing list			
			Full-time re-time search	Research and teaching	Research and extension		Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications		
					Number	Number			Number	Number	Pages		Number	Pages	Number
			Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
Alabama.....	Feb. 27, 1889.....	Apr. 1, 1888.....	35	37	2	1	73	2	68	21	142	6	4,600		
Alaska.....	May 2, 1929.....	May 1, 1931.....	3	1	2		6						522		
Arizona.....	Mar. 19, 1889.....	July 1, 1889.....	18	36	1	1	56	12	429	28	144	33	81		
Arkansas.....	Mar. 7, 1889.....	Apr. 2, 1888.....	16	48	1	2	67	22	807	32	169		12,716		
California.....	Mar. 12, 1889.....	Mar. 13, 1888.....	101	167		1	269	21	1,342	314	628	237	7,154		
													14,700		
Colorado.....	Mar. 25, 1889.....	Feb. 20, 1888.....	30	37			67	15	535	18	86		525		
Connecticut.....															
State.....	May 18, 1887.....	May 18, 1887.....	48				48	24	1,027	28	56	14	15,000		
Storrs.....	do.....	Apr. 1, 1888.....	19	12	2	7	40	5	401	19	192		11,000		
Delaware.....	Apr. 14, 1887.....	Feb. 21, 1888.....	12	8	2	4	26	10	467	16	32		9,950		
Florida.....	June 7, 1887.....	Mar. 16, 1888.....	76	8	5	5	94	33	820	47	166	59	121		
Georgia.....	Dec. 24, 1888.....	Feb. 18, 1888.....	46				46	6	218	7	34		8,000		
Hawaii.....	Mar. 31, 1911.....	July 1, 1929.....	24	15			39	5	321	18	85		1,700		
Idaho.....	Jan. 23, 1891.....	Feb. 26, 1892.....	16	29	2	4	51	7	167	8	42	18	90		
Illinois.....	May 11, 1887.....	Mar. 21, 1888.....	61	76	5	9	151	26	1,108	61	423	17	35,172		
Indiana.....	Jan. 19, 1889.....	July 1, 1887.....	83	30	3	2	118	28	878	107	214	12	54		
Iowa.....	Feb. 17, 1888.....	Feb. 17, 1888.....	79	104	15	4	202	37	2,042	79	692	1	128		
Kansas.....	Mar. 3, 1887.....	Feb. 8, 1888.....	34	101			135	17	786	81	162		26,888		
Kentucky.....	Apr. 29, 1888.....	Apr. 29, 1888.....	72	23	5	5	100	17	607	23	42		12,000		
Louisiana.....	July 12, 1888.....	Apr. 5, 1887.....	49	20	1	1	71	18	431				5,000		
Maine.....	Mar. 16, 1887.....	Feb. 16, 1888.....	30	8			38	11	1,217	6	97		19,000		
Maryland.....	Mar. 9, 1888.....	Mar. 9, 1888.....	23	31	4	10	68	14	579	17	109	39	387		
Massachusetts.....	Apr. 20, 1887.....	Mar. 2, 1888.....	68	18			86	29	722	27	164		2,500		
Michigan.....	Apr. 12, 1889.....	Feb. 26, 1888.....	49	82	7	5	143	24	1,088	32	261	21	1,600		
Minnesota.....	Feb. 4, 1889.....	Jan. 26, 1888.....	62	110	1	4	177	18	840	87	174	42	17,000		
													1,179		
Mississippi.....	Jan. 31, 1888.....	Spring 1888.....	32	27		1	60	7	190	21	89		5,000		
Missouri.....	June 11, 1889.....	Jan. 31, 1888.....	21	79	2	2	102	34	1,030	93	186	26	78		
Montana.....	Feb. 16, 1893.....	July 1, 1893.....	24	12	2	9	47	17	586	8	61	7	3,600		
Nebraska.....	Mar. 31, 1887.....	June 14, 1887.....	18	45	2		65	21	653	27			1,400		
Nevada.....	Feb. 8, 1889.....	December 1887.....	13	2			15	4	89				5,250		

New Hampshire.....	Aug. 4, 1887.....	16	31	6	2	55	22	390			9	42	6,000
New Jersey.....	Mar. 5, 1888.....	25	27	1		53	42	984	79	158	12	225	11,490
College.....	Mar. 16, 1887.....	95				95							
State.....	Feb. 28, 1889.....	12	22		2	36	35	565	3	11	4	22	9,065
New Mexico.....													
New York:													
Cornell.....	Mar. 30, 1887.....	32	114		10	156	34	1,510	289	2,008			55,101
State.....	Apr. 30, 1888.....	78				78	20	509	53	106			20,000
North Carolina.....	Mar. 7, 1887.....	46	18	1	5	70	17	542	1	147			1,300
North Dakota.....	Dec. 5, 1889.....	25	17		2	44	9	274					17,500
	Oct. 15, 1890.....												
Ohio.....	Mar. 16, 1887.....	112				112	28	1,175	51	102			31,946
Okahoma.....	Oct. 27, 1890.....	27	62			89	14	761	33	101			6,000
Oregon.....	Aug. 14, 1891.....	56	55		6	117	15	545	27	54	13	90	1,090
Pennsylvania.....	Feb. 25, 1889.....		162			162	15	560	50	415	14	174	37,500
Puerto Rico.....	June 30, 1887.....	43				43	6	327	2	17	4	379	2,396
	Aug. 16, 1933.....												
Rhode Island.....	Nov. 3, 1888.....	20	4		5	29	9	269	22	44	4	20	2,391
South Carolina.....	Jan. 1, 1887.....	57	21	1	1	80	7	547	10	63			4,100
South Dakota.....	Dec. 22, 1887.....	7	35		3	43	11	468	25	121	2	4	10,993
Tennessee.....	Mar. 11, 1887.....	46	17			63	6	134	8	49			13,936
Texas.....	July 24, 1887.....	147	2			149	15	1,068	57	295	80	80	68,000
	Apr. 2, 1887.....												
Utah.....	Mar. 8, 1888.....	27	27		5	59	10	532	39	204			2,440
Vermont.....	Nov. 16, 1889.....	18	13		1	32	13	346	6	12			4,200
Virginia.....	Feb. 23, 1888.....	42	12	1	4	59	8	462	22	126			12,000
Washington.....	June 13, 1888.....	60	36			96	40	1,061	20	183	24	221	1,961
West Virginia.....	Mar. 9, 1891.....	23	28	2	6	59	5	152	13	80	8	169	12,000
	June 11, 1888.....												
Wisconsin.....	Feb. 22, 1889.....	49	78	6	34	167	9	483	207	414			62,300
Wyoming.....	July 1, 1887.....	19	27			46	9	491					8,000
	Session of 1889.....												
	Jan. 10, 1891.....												
	Mar. 27, 1891.....												
Total.....		2,244	1,974	73	163	4,454	883	33,623	2,241	9,216	662	3,251	697,944

1 First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

New Hampshire	15,000	15,000	60,000	7,312.55	97,312.55	7,244.67	7,312.55			2,862.10	41,498.85	58,828.17	156,140.72
New Jersey:													
College	15,000	15,000	60,000	26,710.11	116,710.11		597,417.20					597,417.20	116,710.11
State	15,000	15,000	60,000	12,040.88	102,040.88	35,742.00	15,041.00			15,385.93		66,168.93	507,417.20
New Mexico	15,000	15,000	60,000										168,209.81
New York:													
Cornell	13,500	13,500	54,000	70,742.42	151,742.42		747,199.63		1,500.00	95,054.73	1,829.41	845,583.77	997,326.19
State	1,500	1,500	6,000	7,860.26	16,860.26	2,087.11	375,618.94			16,610.49		394,316.54	411,176.80
North Carolina	15,000	15,000	60,000	89,799.50	179,799.50	3,736.33	86,697.28			14,595.48		112,511.89	292,311.39
North Dakota	15,000	15,000	60,000	21,591.29	111,591.29	50,080.18		200.00	1,731.55	44,381.15		96,392.88	207,984.17
Ohio	15,000	15,000	60,000	81,387.92	171,387.92	320,703.76	436,618.77			101,159.20	5,928.00	864,409.73	1,035,797.65
Oklahoma	15,000	15,000	60,000	59,894.48	149,894.48	45,461.35	206,016.92		48,595.00	38,473.18		338,546.45	488,440.93
Oregon	15,000	15,000	60,000	17,653.83	107,653.83	107,550.45	309,814.80		4,684.59	46,181.32		510,490.59	618,144.42
Pennsylvania	15,000	15,000	60,000	117,853.33	207,853.33	2,787.95	127,218.00			24,248.49	23,929.82	178,184.26	386,037.59
Puerto Rico	15,000	15,000	12,500	42,483.14	84,983.14		163,739.15					163,729.15	248,712.29
Rhode Island	15,000	15,000	60,000	1,980.86	91,980.86	2,057.95				11,304.19		13,362.14	105,343.00
South Carolina	15,000	15,000	60,000	52,031.84	142,031.84	8,295.08	61,354.00			104,464.81		174,113.89	316,145.73
South Dakota	15,000	15,000	60,000	21,378.38	111,378.38	12,178.68	23,290.00		3,402.34	19,303.65		58,144.67	169,523.05
Tennessee	15,000	15,000	60,000	65,435.90	155,435.90		40,065.51			35,081.52		75,147.03	230,582.93
Texas	15,000	15,000	60,000	130,694.16	220,694.16	88,606.92	357,883.00		7,050.00	174,474.17	103,270.60	731,284.69	951,978.85
Utah	15,000	15,000	60,000	9,100.72	99,100.72	1,824.87	40,300.00		2,600.00	13,750.30	437.40	58,912.57	158,103.29
Vermont	15,000	15,000	60,000	9,162.65	99,162.65	1,136.64				26,698.48	221.33	28,086.45	127,219.11
Virginia	15,000	15,000	60,000	62,251.49	152,251.49		100,995.00			12,288.77		113,284.77	266,536.26
Washington	15,000	15,000	60,000	25,826.26	115,826.26		179,015.45		1,920.20	36,180.80		217,116.45	332,942.71
West Virginia	15,000	15,000	60,000	47,086.76	137,086.76	3,968.92	45,937.50			32,566.78	1,800.00	84,273.20	221,359.96
Wisconsin	15,000	15,000	60,000	52,696.77	142,696.77		289,194.00		115,416.00	88,714.00		493,324.00	636,020.77
Wyoming	15,000	15,000	60,000	5,914.58	95,914.58	34,751.21	57,462.78			27,871.68		120,670.48	216,585.06
T Total	765,000	757,500	2,918,750	2,100,000.00	6,541,250.00	1,471,878.31	9,274,043.21	496,344.43	579,206.47	1,921,272.89	338,763.30	14,081,508.61	20,622,758.61

¹ Including unexpended balances—Alaska, Bankhead-Jones, \$152.86; Connecticut Storrs, Hatch \$5.94, Purnell \$67.67, Bankhead-Jones \$28.88; Illinois, Adams \$0.69; North Dakota Hatch \$1.27, Adams \$1.68, Purnell \$0.28, Bankhead-Jones \$6.26; Puerto Rico, Hatch \$2.96, Adams \$67.83, Purnell \$653.64, Bankhead-Jones \$2,140.30.

TABLE 3.—Expenditures from Federal appropriations received under

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$15,000	\$10,905.00	\$1,519.97	\$461.37	\$308.42	\$105.78	\$7.50	\$48.96	\$125.31
Alaska.....	15,000	6,735.22	4,467.98	175.06	91.80	553.66	488.84	42.12	379.82
Arizona.....	15,000	13,871.09	500.00	-----	14.75	-----	-----	-----	-----
Arkansas.....	15,000	8,643.89	2,115.94	1,544.20	194.27	-----	58.28	676.12	332.59
California.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----	-----
Colorado.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----	-----
Connecticut:									
State.....	7,500	6,807.50	692.50	-----	-----	1.20	-----	-----	-----
Storrs.....	7,500	4,599.93	293.49	1.81	131.01	15.55	177.32	143.90	156.43
Delaware.....	15,000	8,415.79	1,548.22	891.10	1,368.37	-----	-----	180.44	126.57
Florida.....	15,000	14,429.00	571.00	-----	-----	-----	-----	-----	-----
Georgia.....	15,000	7,820.00	1,933.76	957.47	945.91	33.68	847.35	22.76	563.17
Hawaii.....	15,000	10,461.85	2,622.50	829.89	77.00	21.60	-----	-----	.50
Idaho.....	15,000	9,195.29	1,277.11	1,259.12	1,510.82	6.58	-----	190.48	7.62
Illinois.....	15,000	14,823.30	176.70	-----	-----	-----	-----	-----	-----
Indiana.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----	-----
Iowa.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----	-----
Kansas.....	15,000	9,400.00	4,822.31	11.78	22.14	-----	-----	197.11	92.90
Kentucky.....	15,000	14,442.40	-----	510.30	-----	-----	-----	-----	-----
Louisiana.....	15,000	8,175.00	4,685.65	727.80	244.06	2.62	65.19	11.40	132.26
Maine.....	15,000	8,208.37	988.38	4.50	869.41	92.85	1,489.37	207.33	154.58
Maryland.....	15,000	10,656.42	2,181.05	.40	176.48	249.31	106.93	131.08	166.67
Massachusetts.....	15,000	14,587.02	-----	-----	-----	-----	-----	-----	-----
Michigan.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----	-----
Minnesota.....	15,000	14,500.39	62.10	-----	-----	2.14	-----	66.75	15.75
Mississippi.....	15,000	7,012.50	1,496.06	630.70	1,053.11	16.34	117.67	-----	100.34
Missouri.....	15,000	14,310.50	689.50	-----	-----	-----	-----	-----	-----
Montana.....	15,000	8,022.39	4,113.25	216.04	1,178.78	7.74	400.00	116.03	80.92
Nebraska.....	15,000	14,100.00	900.00	-----	-----	-----	-----	-----	-----
Nevada.....	15,000	7,760.53	1,133.93	176.70	666.50	85.88	289.41	-----	285.34
New Hampshire.....	15,000	8,880.20	498.35	316.65	986.92	311.03	700.00	164.34	43.05
New Jersey.....	15,000	10,209.17	413.03	222.08	362.56	8.89	311.87	142.41	274.58
New Mexico.....	15,000	9,115.97	3,267.63	808.25	220.34	66.46	110.86	319.13	364.23
New York:									
Cornell.....	13,500	8,860.00	2,433.66	-----	45.62	16.93	-----	926.86	190.92
State.....	1,500	850.00	539.85	-----	-----	-----	-----	110.15	-----
North Carolina.....	15,000	10,640.00	252.41	501.52	605.67	38.62	-----	13.20	113.78
North Dakota.....	15,000	10,031.99	815.61	757.36	271.85	25.18	166.79	254.23	75.21
Ohio.....	15,000	7,183.34	-----	162.30	316.52	79.86	529.86	1,237.92	288.28
Oklahoma.....	15,000	5,978.32	4,668.52	-----	43.28	24.44	23.74	697.75	746.78
Oregon.....	15,000	6,687.07	4,927.14	892.05	1,259.84	-----	133.70	221.50	138.42
Pennsylvania.....	15,000	8,590.88	2,545.58	2,794.12	-----	16.36	37.50	421.10	80.23
Puerto Rico.....	15,000	9,413.34	719.20	861.59	213.87	9.88	-----	48.64	149.06
Rhode Island.....	15,000	8,944.03	2,505.45	482.75	604.23	33.09	165.02	368.25	505.34
South Carolina.....	15,000	9,854.68	1,648.07	802.42	352.46	3.64	11.28	167.14	159.30
South Dakota.....	15,000	7,652.00	2,951.53	1,039.04	288.23	91.70	42.75	875.94	143.84
Tennessee.....	15,000	8,450.00	3,665.31	306.06	902.26	58.17	30.50	20.34	135.62
Texas.....	15,000	13,521.10	-----	-----	92.11	-----	-----	8.78	-----
Utah.....	15,000	8,937.54	2,096.42	459.49	22.18	9.44	-----	556.80	469.99
Vermont.....	15,000	8,075.58	2,071.50	1,388.48	344.13	37.32	1,064.09	227.50	406.69
Virginia.....	15,000	8,997.57	4,907.25	-----	57.18	-----	10.55	8.60	143.39
Washington.....	15,000	10,522.42	2,308.88	791.20	74.63	3.54	14.06	154.20	86.11
West Virginia.....	15,000	9,960.00	2,478.10	177.81	23.10	118.16	-----	413.40	278.33
Wisconsin.....	15,000	12,335.17	134.12	1,678.51	3.71	1.61	-----	41.46	5.48
Wyoming.....	15,000	6,358.35	4,295.63	1,070.70	492.55	10.03	565.95	216.84	644.48
Total.....	765,000	532,932.10	88,934.64	23,910.62	16,436.07	2,159.28	7,966.38	9,650.96	8,163.88

the act of Mar. 2, 1887 (Hatch Act) for the year ended June 30, 1939

Expenditures—Continued

Fertilizers	Feeds	Library	Vehicles, tools, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
\$167.60		\$450.27	\$217.69	\$136.39	\$58.50		\$66.87	\$21.76	\$398.61		
49.00	\$973.38		730.82	29.80	3.00	\$265.00	4.00	10.50			
1.50	560.15	72.83	95.36	222.46	72.50		319.20				
				250.72	300.00		154.15				
362.20	370.20	1,070.66	6.35	21.59	299.15	23.00					\$19.08
62.11		873.49	53.72	565.48	87.65		629.39	4.80			
	37.20	526.07	152.08	189.11	6.15		921.99	28.19	15.11		
	277.14	48.82	132.00		528.70						
	292.00		8.60	84.75	30.29		1,116.17	21.17			
		16.15	23.28	12.04	12.88		358.41		31.00		
							47.30				
178.74		2.50	438.42	192.90			143.46				
		1,010.98	193.43	783.70	5.44		860.05	34.87	96.74		
92.49	936.50		171.79			4.00	14.90	55.72	56.26		
							412.98				
				65.20	91.56		196.11				
		29.20	750.36	1,623.45	338.73		1,095.89	20.36	715.29		
	46.15	30.09	260.64	227.51	4.00		263.35	27.75	5.36		
	1,186.34	18.76	27.50	924.91	157.23	1,893.68	141.32	85.70	166.27		
		634.91	15.95	1,101.53	790.08		525.46	31.53			
53.97	360.00	302.06	58.17	253.58	474.42		898.32	46.59	608.30		
29.60		4.30	187.96	36.00	91.40		207.39	170.48			
			613.17	1.40	411.44						
107.74			830.48	544.30	328.45		1,023.83				
	160.00	79.56	1,019.92	411.87	348.02		575.63		6.58		.20
691.82	1,845.82		1,170.21	46.20	44.00	526.00	253.83	112.19	511.85		
231.91	736.89		233.00	475.99	690.09	400.00	49.29				
		1.12	69.10	26.63			588.63	54.80			
			35.96	106.63	371.64						
		10.50	2,310.66	1,124.96			99.45	1.60			37.25
88.50	10.75	60.75	285.45	122.03	188.85		237.39		398.12		
74.73	474.81	525.09	345.71	82.75	178.69		307.98	2.45	8.80		
24.50	571.89	10.75	114.57	610.58	157.25	83.58	341.85				
12.95		529.58	240.37	258.42	176.75		107.03	13.95	92.69		
		15.12		306.18			847.10		209.61		
	1,403.37	31.43	104.97	10.30		62.50	835.57				
89.77		191.30	194.76	132.58	283.20		378.40	6.22	108.48		
178.68	2.20		654.81	12.12					27.65		
		142.33	198.17		19.38		652.08	33.00			
40.93	245.95	5.00	587.13		174.30		474.95		22.84		
2.70	18.45						778.79				
	617.00	12.00	232.25		130.41		93.81	2.06	257.94		
2,541.44	11,126.19	6,705.62	10,454.15	11,929.04	7,929.83	3,557.76	16,022.32	785.69	3,737.50		56.53

TABLE 4.—Expenditures from Federal appropriations received under

Station	Amount of appropriation	Expenditures						
		Salaries	Labor	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$15,000	\$9,357.00	\$2,150.51	\$36.07	\$158.86	\$469.43	\$1,370.74	\$94.88
Alaska.....	7,500	1,425.98	4,292.92		239.27		40.35	268.16
Arizona.....	15,000	9,070.15	3,193.01	20.25	47.32	51.71	597.10	90.11
Arkansas.....	15,000	9,507.08	1,749.27	75.12		570.29	1,457.54	106.04
California.....	15,000	15,000.00						
Colorado.....	15,000	15,000.00						
Connecticut:								
State.....	7,500	7,122.00	378.00					
Storrs.....	7,500	6,300.00	1,200.00					
Delaware.....	15,000	11,417.60	1,121.45	1.80	84.00		720.52	25.99
Florida.....	15,000	13,100.00	250.00		11.51		79.89	
Georgia.....	15,000	9,918.34	1,967.42	.47	140.11	792.94	325.12	72.93
Hawaii.....	15,000	9,838.90	2,981.70		.88		760.19	11.99
Idaho.....	15,000	11,353.94	2,036.31	12.71	48.66		872.56	17.41
Illinois.....	15,000	7,297.94	7,640.05					
Indiana.....	15,000	12,757.50	1,178.73	3.61	7.97		565.45	13.98
Iowa.....	15,000	14,864.75						
Kansas.....	15,000	10,300.00	2,755.29		2.07		519.56	4.10
Kentucky.....	15,000	14,565.80	40.00		7.61	3.09	295.30	30.09
Louisiana.....	15,000	10,829.17	2,073.64	19.63	42.76	134.71	564.17	105.82
Maine.....	15,000	10,766.52	2,940.76		2.36		168.50	127.88
Maryland.....	15,000	13,712.41		158.46	1.30		99.47	29.33
Massachusetts.....	15,000	15,000.00						
Michigan.....	15,000	15,000.00						
Minnesota.....	15,000	14,551.33	13.65				6.76	
Mississippi.....	15,000	9,480.83	4,171.48	5.90	21.39	310.10	118.30	258.07
Missouri.....	15,000	3,791.61	5,888.29	80.72	68.63	48.44	1,102.52	81.73
Montana.....	15,000	12,619.35	678.47	18.27	23.18	5.60	515.98	39.06
Nebraska.....	15,000	15,000.00						
Nevada.....	15,000	11,110.50	2,992.77	64.75	12.30		363.02	101.57
New Hampshire.....	15,000	12,607.10	621.47	.75	11.82		244.10	34.31
New Jersey.....	15,000	12,060.00	163.74	44.19		355.17	1,158.63	138.63
New Mexico.....	15,000	9,135.54	3,143.61	104.90	189.27	331.11	1,093.84	91.83
New York:								
Cornell.....	13,500	12,963.34	449.58	9.84			5.95	55.69
State.....	1,500	1,500.00						
North Carolina.....	15,000	11,664.00	965.61	35.15	35.95	9.34	660.79	118.04
North Dakota.....	15,000	11,318.84	915.45	176.05	136.55	225.42	310.48	3.84
Ohio.....	15,000	12,099.84		27.07		525.48	439.63	47.42
Oklahoma.....	15,000	7,159.14	3,181.83		1.19		1,148.88	90.55
Oregon.....	15,000	10,514.43	2,520.40	14.78	4.19		1,034.89	43.41
Pennsylvania.....	15,000	14,880.00	120.00					
Puerto Rico.....	15,000	5,483.34	2,521.73	10.93	95.81	28.53	422.46	804.49
Rhode Island.....	15,000	11,215.01	2,388.67				58.16	12.75
South Carolina.....	15,000	10,291.10	1,005.87	231.20	15.11	457.03	451.53	54.17
South Dakota.....	15,000	7,082.91	5,618.53	67.84	46.20	9.50	852.86	73.09
Tennessee.....	15,000	12,039.98	1,119.50	2.32	15.46	103.10	423.80	118.14
Texas.....	15,000	14,275.00	575.86	60.52			6.98	6.03
Utah.....	15,000	9,820.86	2,496.33	80.56	15.93		936.85	205.90
Vermont.....	15,000	9,808.72	3,523.80	14.54	11.53	85.06	332.79	170.24
Virginia.....	15,000	11,481.30	1,514.27	4.50	36.50	12.50	105.05	102.62
Washington.....	15,000	12,112.72	1,407.21	4.35		1.38	523.66	70.37
West Virginia.....	15,000	11,216.60	2,583.40		1.66	42.88	114.27	62.61
Wisconsin.....	15,000	12,007.00	1,950.00		7.46		16.63	
Wyoming.....	15,000	11,660.60	1,195.94	33.31	57.03		708.19	174.41
Total.....	757,500	574,456.07	91,176.52	1,420.56	1,601.84	4,572.81	21,593.46	3,957.68

the act of Mar. 16, 1906 (Adams Act) for the year ended June 30, 1939

Expenditures—Continued

Ferti- lizers	Feeds	Library	Vehicles, tools, etc.	Furni- ture, fixtures, etc.	Scien- tific ap- paratus	Live- stock	Travel	Con- tingent	Build- ings	Land	Balance
\$8. 70	\$17. 00	-----	\$217. 62	\$459. 08	\$332. 47	-----	\$186. 10	\$0. 78	\$140. 76	-----	-----
563. 25	472. 47	-----	-----	-----	-----	\$50. 00	-----	14. 50	133. 10	-----	-----
55. 59	-----	-----	56. 17	117. 75	378. 89	-----	1, 320. 52	1. 43	-----	-----	-----
290. 68	283. 80	-----	41. 28	-----	425. 03	-----	356. 16	-----	137. 71	-----	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9. 05	-----	\$2. 43	21. 73	-----	1, 002. 21	-----	593. 22	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
-----	1, 023. 30	2. 00	39. 54	20. 25	1, 558. 60	-----	-----	-----	-----	-----	-----
64. 67	-----	-----	30. 50	-----	306. 59	336. 95	21. 65	-----	32. 39	-----	-----
-----	5. 00	-----	72. 15	-----	1, 311. 17	-----	159. 85	1. 10	15. 90	-----	-----
-----	-----	-----	-----	-----	404. 41	-----	-----	-----	-----	-----	\$62. 01
6. 67	88. 00	-----	15. 74	-----	202. 50	102. 00	55. 85	2. 00	-----	-----	-----
-----	-----	-----	135. 25	-----	-----	-----	-----	-----	-----	-----	-----
-----	284. 75	25. 13	5. 00	-----	287. 00	141. 72	175. 38	-----	500. 00	-----	-----
48. 85	254. 18	-----	222. 99	33. 58	45. 41	-----	12. 70	-----	-----	-----	-----
-----	-----	-----	-----	-----	252. 32	3. 50	385. 15	3. 25	29. 28	-----	-----
201. 55	105. 65	6. 44	506. 12	-----	909. 57	-----	174. 22	-----	-----	-----	-----
-----	-----	-----	89. 46	-----	-----	-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	45. 05	383. 21	-----	-----	-----	-----	-----	-----
11. 63	-----	3. 75	195. 75	3. 75	171. 98	-----	108. 12	-----	138. 95	-----	-----
60. 56	3, 398. 89	-----	417. 92	-----	316. 38	12. 00	15. 57	20. 00	196. 74	-----	-----
12. 08	-----	3. 00	9. 81	-----	449. 63	-----	623. 79	1. 78	-----	-----	-----
-----	263. 20	-----	2. 75	-----	2. 16	-----	76. 98	10. 00	-----	-----	-----
-----	9. 25	-----	1. 25	4. 20	1, 236. 27	-----	60. 45	-----	139. 03	\$30. 00	-----
1. 60	-----	1. 65	205. 60	48. 94	756. 98	-----	16. 98	27. 46	20. 43	-----	-----
57. 40	-----	24. 03	133. 69	26. 58	466. 20	-----	89. 51	112. 49	-----	-----	-----
15. 60	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
16. 20	9. 40	-----	182. 42	96. 74	493. 47	49. 40	637. 90	-----	25. 59	-----	-----
-----	326. 61	23. 81	185. 22	128. 12	1, 126. 95	-----	122. 66	-----	-----	-----	-----
-----	718. 46	-----	155. 65	30. 00	572. 30	253. 60	31. 15	-----	127. 40	-----	-----
29. 10	1, 437. 41	19. 80	39. 07	12. 00	1, 692. 93	-----	31. 84	-----	156. 26	-----	-----
-----	3. 78	-----	35. 00	-----	259. 34	-----	546. 32	16. 91	6. 55	-----	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
127. 71	-----	-----	96. 90	63. 40	3, 773. 34	-----	1, 416. 29	-----	155. 07	-----	-----
105. 29	1, 159. 90	-----	6. 30	-----	53. 92	-----	-----	-----	-----	-----	-----
274. 49	265. 28	69. 45	676. 69	127. 75	514. 74	-----	444. 75	4. 90	115. 94	-----	-----
-----	86. 10	213. 69	110. 83	61. 76	397. 50	115. 89	263. 30	-----	-----	-----	-----
33. 12	-----	23. 78	193. 85	24. 79	743. 75	-----	106. 83	3. 65	18. 73	29. 20	-----
-----	75. 61	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
26. 42	64. 13	6. 97	84. 68	11. 15	718. 29	-----	258. 68	-----	299. 67	-----	-----
30. 97	397. 71	3. 38	342. 31	24. 50	608. 95	-----	42. 75	-----	5. 01	-----	-----
-----	-----	-----	35. 93	22. 57	199. 52	-----	321. 95	. 55	724. 06	10. 00	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
32. 31	432. 01	58. 29	67. 38	25. 00	137. 90	-----	588. 74	3. 00	-----	-----	-----
-----	943. 91	-----	125. 66	-----	388. 60	-----	-----	-----	-----	-----	-----
-----	146. 82	6. 50	-----	79. 75	75. 00	-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	70. 89	237. 50	479. 21	5. 50	144. 35	-----	-----
2, 080. 49	12, 272. 62	494. 10	4, 758. 21	1, 466. 71	23, 026. 37	1, 302. 56	9, 696. 57	229. 30	3, 262. 92	69. 20	62. 01

TABLE 5.—Expenditures from Federal appropriations received under

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$60,000	\$40,387.78	\$8,621.93	\$82.31	\$278.00	\$355.04	\$1,128.31	\$1,244.97	\$304.68
Alaska.....	1,250	387.21	678.86			63.68			120.25
Arizona.....	60,000	38,052.78	6,166.30	1,584.82	173.83	120.97	535.08	3,768.69	404.69
Arkansas.....	60,000	44,933.85	3,971.80	1,729.20	558.40	2.71	486.61	1,298.69	394.10
California.....	60,000	60,000.00							
Colorado.....	60,000	48,599.26	5,334.37	34.86	443.10	59.10	90.35	706.17	442.26
Connecticut:									
State.....	30,000	25,150.00	1,513.61	36.42	40.31	23.25	480.25	582.56	248.20
Storrs.....	30,000	23,753.87	3,109.64		709.18	4.05	55.00	1,195.81	137.37
Delaware.....	60,000	40,134.60	6,037.73	1,572.40	87.54	79.01	620.57	1,005.36	455.41
Florida.....	60,000	44,549.00	7,985.95		267.16	28.95	37.07	2,057.01	228.09
Georgia.....	60,000	30,582.91	15,014.51	1,216.57	197.39	151.78	2,649.56	875.32	1,873.51
Hawaii.....	25,000	19,234.16	4,913.00		6.88		12.75	380.39	77.18
Idaho.....	60,000	42,450.53	8,071.40	195.01	1,176.71	125.17	111.57	1,659.22	30.39
Illinois.....	60,000	34,300.09	11,285.08	2,868.56	2,215.92	26.26		2,402.31	49.71
Indiana.....	60,000	46,999.67	5,003.93	5.74	389.28	187.07	7.91	946.37	42.31
Iowa.....	60,000	58,883.77		976.74					
Kansas.....	60,000	37,500.00	18,831.99	41.12	19.86	9.80	24.58	1,302.29	85.80
Kentucky.....	60,000	47,031.41	2,029.69	2,156.32	201.28	10.36	1.80	494.05	314.08
Louisiana.....	60,000	42,259.49	9,637.47	340.00	310.08	142.11	165.80	958.99	471.33
Maine.....	60,000	40,846.20	7,728.89	65.04	34.08	53.87	300.06	1,085.87	496.50
Maryland.....	60,000	43,803.97	2,290.92	1,281.33	437.10	91.69	11.65	1,473.14	742.51
Massachusetts.....	60,000	52,282.42	1,599.30	1,136.62	26.11			1,196.58	106.02
Michigan.....	60,000	51,105.56	3,076.26	96.09	334.61	20.22		960.22	628.09
Minnesota.....	60,000	52,437.06	1,426.14	404.72	56.71	140.31		1,392.47	138.33
Mississippi.....	60,000	37,364.64	8,032.33	455.84	690.57	354.61	1,429.29	1,187.53	1,056.59
Missouri.....	60,000	21,596.28	16,274.07	2,004.34	241.34	222.78	479.84	5,357.10	499.34
Montana.....	60,000	41,694.99	9,164.67	2,279.71	560.00	54.45	259.02	964.06	297.39
Nebraska.....	60,000	39,347.78	9,974.44	1,664.68	44.92	24.38	.97	2,514.12	419.57
Nevada.....	60,000	31,997.15	17,339.01	259.33	982.73	116.43	325.43	818.25	1,577.36
New Hampshire.....	60,000	46,690.50	5,219.21	1,055.30	166.66	73.19	34.02	1,073.93	381.80
New Jersey.....	60,000	51,965.22	731.45	110.30	244.87	16.05	143.13	1,550.61	794.62
New Mexico.....	60,000	32,347.37	10,566.27	1,080.99	1,098.49	239.63	474.12	1,141.17	353.97
New York:									
Cornell.....	54,000	35,898.41	6,377.65		454.12	14.10		1,148.83	188.54
State.....	6,000	5,462.50	81.79					455.71	
North Carolina.....	60,000	39,158.50	9,667.31	1,051.66	511.23	68.40	302.44	287.48	523.91
North Dakota.....	60,000	41,318.28	4,082.17	351.80	654.09	304.72	204.60	1,154.97	7.51
Ohio.....	60,000	43,466.56	488.05	204.70	46.24	462.33		836.32	251.78
Oklahoma.....	60,000	24,014.61	15,790.94	306.60	111.90	10.30	61.61	1,754.30	433.88
Oregon.....	60,000	40,246.54	12,086.14	1,324.94	776.46	77.98	60.90	1,049.18	207.88
Pennsylvania.....	60,000	46,661.67	5,101.64		215.11	43.54	72.26	1,800.64	252.45
Puerto Rico.....	12,500	6,246.68	3,015.59	397.36	97.71				
Rhode Island.....	60,000	40,626.56	11,586.77	409.67	136.77	33.53	403.11	948.04	194.02
South Carolina.....	60,000	44,435.05	4,427.87	1,652.06	1,130.36	107.28	132.47	1,105.84	188.59
South Dakota.....	60,000	31,664.96	12,009.98	2,325.29	1,130.97	381.07	94.56	2,107.19	350.26
Tennessee.....	60,000	46,789.87	6,207.31	676.95	251.72	151.37	229.08	723.96	515.64
Texas.....	60,000	42,129.98	11,924.10	.95	450.42	66.81	63.24	1,056.09	253.27
Utah.....	60,000	36,894.90	13,919.85	1,473.97	544.39	14.60	63.75	703.34	503.02
Vermont.....	60,000	38,571.76	9,520.58	361.91	670.32	59.28	1,971.89	2,241.85	407.39
Virginia.....	60,000	45,235.30	7,118.11	1,806.70	483.91	18.07	350.59	704.68	86.30
Washington.....	60,000	39,963.54	9,955.82	2,425.76	342.27	43.34		971.70	650.19
West Virginia.....	60,000	41,025.00	7,957.00	863.81	77.25	19.72	675.24	1,639.50	526.17
Wisconsin.....	60,000	53,124.02	5,221.90		12.20	26.12	9.10	284.12	18.38
Wyoming.....	60,000	37,314.90	5,164.54	1,101.59	245.01	164.16	15.00	1,135.57	559.34
Total.....	2,918,750	2,048,919.11	373,335.33	41,470.08	20,335.56	4,863.64	14,574.58	63,702.86	19,289.97

the act of Feb. 24, 1925 (Purnall Act) for the year ended June 30, 1939

Expenditures—Continued

Ferti- lizers	Feeds	Li- brary	Vehi- cles, tools, etc.	Furni- ture, fix- tures, etc.	Scien- tific appa- ratus	Live- stock	Travel	Con- tin- gent	Build- ings	Land	Balance
\$36.75	\$2,005.11	\$58.55	\$277.27	\$300.59	\$2,193.42	\$56.25	\$485.11	\$56.86	\$2,127.07	-----	-----
636.66	892.02	16.46	183.52	1,835.79	2,636.99	190.80	2,297.16	11.41	428.86	\$50.00	\$13.20
171.44	250.72	131.74	52.57	102.41	3,421.56	-----	1,856.67	-----	541.43	96.10	-----
11.75	711.79	40.12	385.11	53.11	1,174.33	25.48	1,742.18	1.51	64.15	81.00	-----
216.66	-----	119.25	80.25	22.58	717.53	-----	383.83	8.10	377.20	-----	43.58
44.81	46.05	44.88	7.60	253.65	216.13	70.32	189.30	118.76	-----	-----	-----
227.23	3,231.28	91.30	937.26	75.21	1,382.80	84.00	3,497.42	29.50	226.38	225.00	-----
89.10	748.23	4.10	151.06	85.31	1,100.44	155.50	2,509.79	-----	3.24	-----	-----
1,163.21	2,367.97	202.15	1,517.43	199.73	355.22	235.00	1,000.82	9.93	356.99	-----	-----
79.51	-----	.89	-----	-----	57.39	-----	137.85	-----	-----	100.00	-----
-----	862.28	39.34	701.52	155.15	1,986.23	55.00	2,196.02	53.85	30.61	100.00	-----
-----	-----	24.99	728.87	581.26	1,322.49	-----	3,186.01	50.36	852.10	-----	105.99
-----	306.18	30.50	257.09	229.10	1,343.72	-----	4,157.42	61.40	32.31	-----	-----
-----	-----	-----	-----	139.49	-----	-----	-----	-----	-----	-----	-----
-----	276.20	17.81	270.18	48.70	1,127.47	61.34	304.89	4.85	53.12	20.00	-----
-----	6.45	-----	39.47	1,075.45	3,152.66	-----	3,486.98	-----	-----	-----	-----
613.98	493.44	3.00	1,097.84	35.81	918.29	76.30	1,280.56	5.60	1,189.91	-----	-----
1,753.63	735.75	13.11	2,506.77	85.46	387.22	1,356.99	2,117.61	.25	432.70	-----	-----
367.24	187.54	28.36	1,681.20	713.34	2,686.73	77.55	2,067.01	-----	2,013.72	45.00	-----
-----	677.41	190.06	180.65	82.55	1,422.60	193.02	903.04	3.62	-----	-----	-----
-----	182.54	41.19	31.63	417.52	1,588.26	-----	1,398.17	119.64	-----	-----	-----
-----	1,532.15	6.58	31.25	69.81	901.88	-----	1,389.80	60.32	12.47	-----	-----
396.38	701.66	33.97	2,783.63	444.66	1,032.99	484.13	1,875.17	48.23	1,627.78	-----	-----
140.25	5,566.92	13.60	1,327.14	275.02	2,892.62	-----	1,753.67	111.00	1,244.69	-----	-----
19.48	369.29	23.55	1,275.53	134.21	844.90	-----	1,162.91	27.20	60.44	808.20	-----
-----	585.08	47.58	54.24	302.82	2,471.06	175.00	1,129.10	-----	1,244.26	-----	-----
-----	1,628.91	48.39	496.73	707.20	585.99	329.90	2,262.46	76.71	448.02	-----	-----
325.02	483.82	23.75	20.68	173.56	1,539.66	7.00	2,290.27	15.11	64.52	362.00	-----
215.54	80.92	58.32	581.05	143.85	2,289.49	-----	715.06	122.04	237.48	-----	-----
109.37	2,699.78	32.51	898.75	1,507.48	2,558.54	1,070.65	2,861.98	449.14	202.29	307.50	-----
-----	-----	133.64	216.22	351.71	7,122.63	-----	2,033.31	18.95	-----	-----	41.89
107.09	2,937.24	30.00	558.66	986.74	1,254.19	100.00	2,237.02	1.02	192.11	25.00	-----
-----	5,755.77	224.09	933.83	518.31	2,173.89	1,079.50	959.55	21.99	254.93	-----	-----
8.70	6,131.24	-----	538.47	44.05	797.97	5,541.25	498.49	-----	683.85	-----	-----
-----	6,706.72	.61	1,041.37	683.09	7,590.07	82.50	584.78	4.24	822.48	-----	-----
31.55	842.69	20.52	112.25	306.17	594.77	-----	2,183.48	7.75	24.00	46.80	-----
69.25	1,822.31	-----	586.10	-----	1,108.58	300.00	1,966.45	-----	-----	-----	102.64
-----	-----	-----	-----	1,436.92	-----	-----	1,203.10	-----	-----	-----	-----
307.43	3,146.47	95.03	885.17	33.00	340.38	-----	573.22	-----	280.83	-----	-----
1,055.78	2,494.47	150.02	476.72	337.74	1,149.15	-----	1,092.25	63.35	1.00	-----	-----
-----	1,193.22	521.43	690.07	791.28	1,272.81	1,676.35	3,102.94	1.20	686.42	-----	-----
77.61	287.54	92.02	715.54	165.00	1,705.78	-----	649.24	6.85	754.52	-----	-----
27.79	673.99	43.72	95.46	16.87	1,478.58	130.00	1,292.91	20.05	250.77	25.00	-----
62.11	-----	6.50	974.10	445.26	388.88	-----	2,824.73	79.90	189.45	911.25	-----
3.35	474.88	20.78	1,141.82	641.03	2,173.83	-----	1,441.78	18.17	279.38	-----	-----
-----	140.69	4.08	154.88	338.71	2,611.65	24.92	830.92	.30	90.19	-----	-----
62.92	1,639.55	133.03	832.45	183.62	1,241.93	123.50	1,383.07	29.40	17.91	-----	-----
507.51	1,278.31	5.00	499.32	71.65	1,210.52	1,439.51	1,965.03	2.36	236.80	-----	-----
88.93	97.21	-----	54.45	-----	-----	-----	1,063.57	-----	-----	-----	-----
-----	9,725.00	73.45	167.27	18.73	1,145.79	566.30	2,255.55	10.15	62.65	275.00	-----
9,028.03	72,976.79	2,939.97	29,230.44	17,481.21	79,809.47	15,768.06	80,779.65	1,731.07	18,729.03	3,477.85	307.30

TABLE 6.—Expenditures from Federal appropriations received under the

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	\$72,358.23	\$36,875.03	\$8,177.73	\$15.05	\$139.13	\$1,907.72	\$1,300.23	\$2,467.82	\$1,253.98
Alaska	1,956.92	476.89	246.01	-----	-----	20.28	-----	3.25	31.35
Arizona	10,869.74	7,105.35	915.51	280.25	63.38	6.89	40.68	90.21	13.52
Arkansas	55,985.30	38,735.74	4,236.25	939.58	329.88	61.97	112.26	2,618.72	655.95
California	57,699.21	57,698.21	-----	-----	1.00	-----	-----	-----	-----
Colorado	19,627.09	6,626.87	7,210.61	-----	448.20	147.70	-----	680.40	142.61
Connecticut	-----	-----	-----	-----	-----	-----	-----	-----	-----
State	9,037.91	7,983.86	-----	12.20	-----	3.15	571.66	281.58	12.21
Storrs	9,037.91	5,836.20	1,149.45	-----	178.21	2.91	43.61	119.26	165.08
Delaware	4,383.93	3,600.00	31.14	-----	-----	5.00	-----	164.33	-----
Florida	26,951.43	6,954.00	10,669.21	-----	45.77	48.66	565.78	871.78	720.51
Georgia	76,582.56	34,687.06	11,762.81	-----	466.01	779.77	3,067.17	1,110.61	1,568.32
Hawaii	8,038.10	5,970.00	1,345.00	-----	-----	-----	-----	219.64	4.96
Idaho	12,003.74	6,537.22	2,023.02	-----	49.49	8.62	-----	296.35	.68
Illinois	75,894.45	40,892.56	16,982.95	1,224.48	645.89	216.33	558.41	3,871.72	1,188.63
Indiana	54,882.28	27,944.00	7,705.49	-----	97.79	81.46	-----	3,284.53	185.22
Iowa	56,747.81	49,139.83	3,014.60	121.48	-----	21.90	3.63	-----	3,834.37
Kansas	43,794.59	22,100.00	8,921.96	-----	35.39	-----	-----	986.67	223.28
Kentucky	69,070.78	48,192.66	2,071.31	713.03	210.40	93.39	-----	1,623.49	450.58
Louisiana	48,241.76	31,895.05	6,354.15	11.44	125.53	124.05	221.17	1,096.76	302.53
Maine	18,105.64	13,273.22	2,638.44	-----	3.32	39.80	-----	130.02	144.96
Maryland	24,981.67	17,017.59	2,495.39	56.46	245.15	127.50	175.89	666.25	447.15
Massachusetts	15,909.43	15,909.43	-----	162.55	-----	-----	-----	-----	-----
Michigan	58,596.86	38,961.92	5,040.37	24.09	55.25	36.48	195.22	2,100.95	582.27
Minnesota	49,697.93	34,126.13	3,699.33	381.14	49.89	125.21	-----	2,889.42	60.70
Mississippi	63,569.98	25,235.60	11,706.37	97.71	394.35	763.91	2,460.38	1,800.64	1,775.53
Missouri	67,346.82	19,919.02	16,869.49	1,598.53	482.14	536.23	708.21	7,212.11	591.88
Montana	13,545.27	8,147.26	4,367.39	-----	24.00	-----	-----	153.21	185.61
Nebraska	33,929.52	21,047.91	6,645.67	104.00	65.28	.65	7.80	241.91	78.25
Nevada	2,153.06	1,400.00	187.50	-----	-----	-----	-----	-----	37.89
New Hampshire	7,312.55	4,018.60	1,724.44	2.35	89.76	1.73	-----	94.62	43.19
New Jersey	26,710.11	17,533.85	1,383.62	50.23	45.57	.44	76.83	549.85	772.39
New Mexico	12,040.88	4,872.13	2,831.46	-----	141.31	141.52	207.03	162.42	332.70
New York	70,742.42	46,421.68	5,469.57	43.79	34.37	41.90	29.13	2,611.65	941.88
Cornell State	7,860.26	5,416.07	714.60	-----	10.18	-----	-----	866.37	-----
North Carolina	89,799.50	61,780.16	9,175.05	44.10	271.72	434.22	327.60	2,433.83	1,771.00
North Dakota	21,591.29	14,439.25	2,435.19	34.57	374.41	169.80	214.20	973.77	3.75
Ohio	81,387.92	51,510.42	113.15	-----	89.33	194.83	1,354.84	809.43	372.06
Oklahoma	59,894.48	17,527.35	16,308.56	229.02	62.02	9.19	207.54	3,022.89	900.93
Oregon	17,653.89	9,903.69	4,102.34	-----	1,017.66	5.43	13.86	683.48	148.20
Pennsylvania	117,853.33	81,426.15	14,767.02	390.86	36.17	185.14	236.36	3,573.77	1,503.09
Puerto Rico	42,483.14	17,416.19	8,783.34	-----	166.56	9.09	3.24	2,707.34	1,653.21
Rhode Island	1,980.86	1,974.76	-----	-----	-----	-----	-----	-----	-----
South Carolina	52,031.84	28,415.57	3,960.13	7.75	417.95	659.21	996.94	1,920.27	297.39
South Dakota	21,378.38	8,639.97	7,728.71	-----	69.85	99.79	69.59	399.48	271.38
Tennessee	65,435.90	31,418.50	13,742.48	-----	245.81	573.29	390.50	2,526.50	1,611.22
Texas	130,694.16	77,956.81	19,448.51	-----	353.26	110.91	203.92	3,120.18	481.13
Utah	9,190.72	4,174.94	3,927.28	-----	144.76	3.52	-----	8.16	39.11
Vermont	9,162.65	5,892.47	2,278.34	-----	57.32	3.82	110.21	90.47	184.34
Virginia	62,251.49	39,862.28	5,707.06	13.30	36.59	101.30	247.58	1,975.35	1,150.38
Washington	25,826.26	15,697.42	3,783.79	7.05	46.82	61.90	12.74	631.30	540.56
West Virginia	47,086.76	26,178.21	8,629.00	311.97	57.98	87.77	622.73	2,690.03	634.60
Wisconsin	52,696.77	42,781.83	6,143.39	-----	20.20	1.60	-----	398.37	141.77
Wyoming	5,914.58	3,663.66	361.18	16.13	67.70	1.61	-----	440.10	7.40
Total	2,100,000.00	1,253,048.02	289,985.36	6,893.11	8,012.75	8,057.59	15,356.94	67,671.26	28,459.70

act of June 29, 1935 (Bankhead-Jones Act) for the year ended June 30, 1939

Expenditures—Continued

Ferti- lizers	Feeds	Library	Vehi- cles tools, etc.	Furni- ture, fixtures, etc.	Scien- tific appa- ratus	Live- stock	Travel	Con- tingent	Build- ings	Land	Bal- ance
\$313.39	\$3,471.82	\$12.89	\$634.11	\$3,417.07	\$4,110.08	\$1.00	\$1,484.61	\$24.40	\$6,752.17		
	404.49		374.65			400.00					
93.86	348.97	25.00	293.06	313.81	54.91		1,620.57			\$33.00	
		18.44	383.41	557.80	3,925.13	98.75	2,536.85	15.00	292.29	24.45	
	1,586.00		594.49	16.86	540.27		1,533.18		99.90		
		33.00	39.86	49.25	6.84		44.30				
22.47	194.34	30.99	234.07	384.75	443.94	21.00	45.80	158.97			\$6.86
		69.39		14.96	455.41		43.70				
777.21	148.75		2,515.92		959.28		1,269.42	8.20	1,396.94		
168.92	2,889.67	174.40	5,037.13	163.48	270.85	6,895.86	2,909.49	42.99	416.13	4,171.89	
			5.00		493.50						
	1,632.60	17.00	15.28		19.98		608.28	30.57	284.65	480.00	
		9.82	2,640.64	887.90	3,283.79	130.00	2,988.15	2.24	299.02		71.92
186.79	360.59		1,089.10	862.76	9,856.75		2,163.39	10.14	1,054.27		
									612.00		
	1,628.10		1,642.13	19.65	2,071.28	500.00	303.73		5,362.40		
3.50	717.36		245.59	318.90	8,336.78		1,118.71		4,975.08		
159.81	1,330.76	5.28	1,290.92	157.04	1,837.10	297.40	1,812.58	34.16	1,186.03		
237.97	475.92	3.77	473.79		47.01	20.00	591.82		25.60		
131.61	330.49	1.68	536.90	92.70	1,195.62	130.75	357.55		637.99	335.00	
174.24	866.16	12.83	2,048.04	1,088.86	5,685.81		1,030.93	26.68	666.76		
25.00	438.04	14.50	362.25	60.70	2,416.15	663.99	2,917.15	17.86	1,130.47	320.00	
213.69	1,643.84	44.64	4,065.00	1,013.99	4,857.51	660.93	1,210.75	54.52	5,137.08	433.54	
60.60	4,128.46	24.50	1,246.09	564.94	4,668.03	102.75	1,299.07	135.87	3,698.90	3,500.00	
	407.04		47.81		184.99		40.94	7.02			
	1,127.99		1,501.85		1,666.89		899.78		541.54		
				239.25	93.73		194.69				
59.28		1.25			69.63		620.12		587.58		
	1,836.77	22.83	937.53	53.51	1,056.52	47.87	1,256.77	53.50	1,032.03		
	746.36	2.66	733.05		592.84	890.00	215.37	4.46	18.84	148.73	
374.13	1,936.33	6.54	3,372.26	408.71	6,076.82	842.20	2,003.64	62.34	65.48		
177.90		5.00			583.60		86.54				
545.98	286.24	9.92	410.99	205.41	3,461.40	21.20	7,097.09	12.95	1,346.64	164.00	
	305.56	102.40	172.15	319.22	1,402.19	230.92	402.55	2.60	8.76		
53.03	484.82	4.75	4,725.32	1,114.65	5,757.76	13,269.00	407.05		742.48	380.00	
68.08	5,890.91		1,004.78	103.85	2,546.11	1,117.21	459.64		10,436.40		
	55.44		13.92		50.23		1,646.38	8.20	5.00		
915.57	2,554.55		2,028.65	27.72	3,057.22	358.07	5,711.22		1,081.77		
146.19	188.10		1,036.53	899.49	4,609.81	60.00	1,598.30		3,109.00		96.75
							6.10				
1,108.96	3,372.40	159.87	4,633.12	114.25	2,081.34	476.25	1,358.00	29.12	1,986.32	37.00	
	2,178.60	50.21	77.05	61.05	1,100.03	370.00	65.85		196.82		
349.50	101.85	17.15	5,307.07	381.68	1,753.93	3,432.23	1,307.93	205.05	2,071.21		
39.90	5,161.76	134.44	1,208.27	243.30	7,163.24	169.30	2,746.69	53.00	12,034.54	15.00	
			107.34		51.87		733.74				
	56.97		115.29	71.60	119.20		7.80	10.67	16+15		
286.11	303.07	46.52	1,591.68	304.87	6,523.18	10.05	1,911.77	9.54	1,210.86		
	854.43	5.63	322.76	250.52	1,850.19	337.57	1,310.47	7.22	105.89		
31.88	1,359.76	24.94	769.34	6.75	3,058.56	232.71	1,676.55	9.60	304.38	400.00	
27.17	2,284.52		12.45		91.80		763.67			30.00	
		7.29	603.14	116.14	259.65		370.58				
6,757.74	55,063.43	1,149.53	56,499.78	14,907.39	110,798.75	31,787.01	62,789.26	1,036.87	71,077.37	10,472.61	175.53

TABLE 7.—Expenditures from supplementary funds received from within the States for the year ended June 30, 1939

Station	Salaries	Labor	Publica- tions	Postage, stationery, telegraph, and tele- phone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers	Feeds
Alabama.....	\$70,019.59	\$47,933.18	\$1,632.16	\$2,365.03	\$2,209.04	\$5,842.16	\$1,666.44	\$7,196.49	\$8,110.94	\$10,387.11
Alaska.....	4,372.53	3,752.91	234.52	234.52	1,127.90	2,128.44	39.49	206.92	2.92	86.20
Arizona.....	61,283.66	22,760.09	3,559.31	2,633.93	318.96	2,935.79	1,839.83	2,609.43	1,010.25	10,049.98
Arkansas.....	56,287.26	15,288.80	192.35	2,461.55	3,255.98	4,665.86	2,954.84	3,777.58	2,219.81	2,426.68
California.....	519,495.76	205,798.31	25,974.78	23,688.31	7,792.44	27,273.53	23,377.58	46,954.62	10,389.92	58,433.27
Colorado.....	54,379.32	20,497.11	3,491.98	1,977.10	1,494.79	6,357.19	1,826.26	2,894.84	107.70	3,473.95
Connecticut.....	7,959.73	18,473.65	293.52	2,312.64	83.97	5,722.57	1,971.83	1,537.93	1,059.42	471.93
State.....	28,481.70	8,818.76	67.91	1,411.33	304.21	692.73	963.89	1,065.34	3,775.01	3,775.01
Storrs.....	7,989.98	15,586.96		760.34	328.59	2,942.71	480.31	3,396.60	665.06	5,014.68
Delaware.....										
Florida.....	196,517.08	107,307.10	12,305.67	7,931.73	2,855.20	15,775.04	8,103.95	11,012.44	7,104.35	20,150.44
Georgia.....	36,351.75	25,461.80	3,883.84	1,337.28	2,292.55	8,333.94	1,548.78	7,066.09	3,141.77	2,273.94
Hawaii.....	59,730.47	12,934.68	3,063.51	2,404.08	423.93	3,560.45	6,851.00	2,362.00	837.00	5,027.00
Idaho.....	22,240.33	8,826.80	853.75	1,066.10	416.00	1,202.00	1,088.04	1,846.20	432.51	2,884.00
Illinois.....	243,000.00	93,297.71	10,000.00	7,000.00			12,000.00	23,882.07	4,000.00	30,000.00
Indiana.....	266,630.71	102,244.24	5,768.92	47,035.74	2,149.41	14,189.49	26,725.53	6,663.72	3,532.23	25,100.90
Iowa.....	153,814.61	42,542.62	14,714.33	3,940.35	1,129.38	1,431.00	6,323.47	14,893.47	7,137.01	7,137.01
Kansas.....	41,010.04	63,804.89	2,442.31	3,309.52	1,558.55	7,252.77	3,157.07	9,227.65	182.56	8,698.42
Kentucky.....	168,818.60	25,762.80	1,861.20	10,352.10	950.72	8,573.00	1,753.52	15,921.22	821.11	10,095.16
Louisiana.....	50,594.34	34,426.95	1,125.66	1,966.99	608.20	4,862.47	2,340.69	2,451.51	1,363.22	1,594.75
Maine.....	30,509.39	16,312.26	86.01	713.96	597.23	3,823.20	1,959.00	5,698.07	174.69	1,241.86
Maryland.....	44,532.36	27,201.62	2,081.57	1,577.96	1,783.26	6,097.65	948.45	2,318.93	1,588.98	14,135.81
Massachusetts.....	141,035.85	41,855.61	3,828.22	2,616.70	1,466.31	1,279.55	4,592.39	5,175.78	722.06	5,068.16
Michigan.....	46,091.61	84,253.06	15,104.37	2,881.57	1,097.02	3,353.07	3,385.59	12,654.52	1,612.03	10,327.23
Minnesota.....	289,243.77	55,851.32	3,661.27	11,152.79	1,655.94	32,110.30	23,001.61	10,830.94		14,604.44
Mississippi.....	66,913.85	35,686.41	2,438.85	1,887.27	768.94	6,626.04	914.77	6,174.20	3,466.12	3,204.53
Missouri.....	55,150.69	56,614.54	6,170.09	4,555.69	1,216.24	1,248.27	7,380.28	14,597.42	1,497.78	13,774.41
Montana.....	55,870.61	17,188.11	2,135.72	3,240.26	1,386.10	3,506.53	769.54	4,658.32	350.77	6,254.61
Nebraska.....	69,073.29	28,227.71	2,637.58	3,442.30	1,141.30	8,305.93	7,833.32	2,377.76	7,477.03	30,166.53
Nevada.....	1,533.50	771.25	61.30	337.43	14.09	708.61	46.22	1,396.05		716.38
New Hampshire.....	21,960.88	5,276.97		645.20	78.22	138.41	3,130.47	415.20	98.96	848.45
New Jersey.....	360,794.61	15,075.13	4,986.21	9,914.35	284.61	15,999.97	14,432.30	1,136.31	1,685.00	25,000.97
New Mexico.....	11,864.38	6,869.32	4,539.38	549.08	281.61	855.02	425.72	1,764.55	1,47.85	3,869.32
New York.....	520,576.02	71,550.11	13,257.30	12,417.87	1,406.36	47,066.69	20,502.58	20,709.52	3,000.00	16,161.06
Cornell.....					2,157.60	15,532.63	7,200.00	14,657.11	3,000.00	3,357.49
State.....	236,108.72	50,043.80	7,055.55	5,373.09						

North Carolina.....	48,137.99	26,005.47	306.15	1,183.99	173.85	763.32	284.12	8,101.05	1,517.87	4,679.45
North Dakota.....	21,953.74	9,760.14	1,550.95	1,858.88	2,032.56	15,788.31	4,467.06	1,664.48	1,032.96	9,792.97
Ohio.....	212,578.14	133,974.50	23,909.10	5,246.57	1,971.39	15,445.89	6,291.43	26,188.91	1,142.57	19,648.75
Oklahoma.....	176,188.55	21,060.60	3,413.77	2,900.69	1,916.27	8,703.23	6,291.54	8,703.23	1,082.32	8,483.42
Oregon.....	116,334.59	102,353.85	3,884.07	4,054.88	1,887.98	8,446.33	7,411.93	14,800.03	1,082.32	12,477.26
Pennsylvania.....	91,060.46	31,001.09	2,400.97	1,748.02	131.16	3,922.80	5,346.42	14,854.53	199.87	12,850.79
Puerto Rico.....	91,868.47	19,878.79	1,670.44	1,757.48	77.92	991.98	1,336.66	2,960.84	1,034.30	735.57
Rhode Island.....	2,409.62	5,162.17	52.47	1,181.04	1,368.41	2,325.16	48.33	551.64	10,658.46	17,572.02
South Carolina.....	36,355.58	43,380.08	446.77	1,793.35	239.47	471.06	1,045.99	313.23	6,223.47	6,223.47
South Dakota.....	10,871.68	7,700.57	1,310.55	342.33	681.37	1,332.11	4,290.55	2,825.76	275.81	4,266.18
Tennessee.....	26,918.92	14,732.55	250.78	670.72	1,061.22	9,539.64	7,784.91	35,851.33	30.00	26,553.10
Texas.....	263,537.15	100,173.74	7,229.52	11,137.31	1,061.22	9,539.64	7,784.91	35,851.33	30.00	1,517.86
Utah.....	22,800.73	11,673.35	2,610.31	2,146.32	106.17	638.00	435.10	2,061.79	76.73	2,550.94
Vermont.....	14,044.12	4,324.85	1,289.20	2,319.11	81.72	693.00	435.10	2,061.79	76.73	2,550.94
Virginia.....	59,283.07	16,045.62	2,417.11	2,187.45	792.94	992.33	1,316.22	1,468.67	949.37	2,523.55
Washington.....	71,817.50	66,814.22	2,141.65	2,986.24	1,063.26	9,484.14	5,854.63	7,746.67	930.90	10,867.36
West Virginia.....	31,646.76	15,135.83	294.70	1,179.23	135.40	4,882.23	604.74	2,829.74	1,518.22	8,830.81
Wisconsin.....	348,568.00	36,691.00	4,947.00	3,553.00	1,070.00	19,307.00	19,307.00	18,997.00	1,400.00	11,516.00
Wyoming.....	35,797.99	35,797.99	4,947.00	3,553.00	838.35	2,399.21	2,399.21	6,647.09	7,638.36	7,638.36
Total.....	5,999,240.05	2,054,873.00	211,900.51	231,407.02	58,021.23	344,348.37	278,367.24	433,511.31	91,991.45	523,050.70

Station	Library	Vehicles, tools, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
Alabama.....	\$520.72	\$8,273.15	\$935.82	\$2,514.87	\$10,328.82	\$11,772.67	\$8,219.71	\$33,041.36	\$7,164.35	\$106,055.36	\$406,188.97
Alaska.....	10.75	1,346.25	86.61	2.60	65.00	1,207.00	580.42	1,674.42	2.19	2.19	17,327.07
Arizona.....	2,803.20	2,787.26	2,787.26	4,664.84	918.68	4,037.00	591.77	6,077.42	1,239.70	1,239.70	126,557.59
Arkansas.....	2,900.36	1,136.74	1,136.74	4,664.84	918.68	4,037.00	591.77	6,077.42	1,239.70	1,239.70	116,934.30
California.....	31,169.74	10,389.92	10,389.92	15,584.87	19,481.09	45,455.88	16,883.61	68,883.19	19,481.09	116,886.55	1,296,739.42
Colorado.....	34.35	3,651.73	134.78	3,571.94	8,705.50	4,934.99	115.59	2,288.95	403.24	14,050.06	134,391.37
Connecticut.....	1,588.17	3,475.68	1,232.64	662.68	255.00	10,253.60	2,635.64	1,500.52	403.24	403.24	249,224.12
State.....	60.93	5.00	153.23	153.23	24.00	631.62	180.32	1,500.52	403.24	403.24	45,315.72
Storrs.....	36.08	1,546.01	3.90	233.56	207.68	668.68	391.73	1,863.89	403.24	403.24	45,146.58
Delaware.....	2,653.48	17,335.31	3,124.99	10,167.10	2,630.56	22,202.88	3,224.55	24,286.48	6,647.60	18,018.85	499,444.80
Florida.....	472.96	5,609.14	1,185.81	1,234.00	3,923.22	4,392.48	3,992.68	10,782.59	2,628.28	2,299.96	124,610.74
Georgia.....	50.97	737.05	306.76	2,322.34	150.00	1,890.90	7,266.39	6,379.67	280.28	280.28	116,614.51
Hawaii.....	300.00	1,506.00	241.00	707.11	950.10	3,784.55	1,261.09	2,039.00	7,218.32	7,218.32	58,862.90
Idaho.....	10,453.61	10,453.61	2,400.00	6,000.00	1,800.00	15,000.00	6,000.00	6,000.00	6,000.00	6,000.00	464,833.39
Illinois.....	10,453.61	10,453.61	2,400.00	6,000.00	1,800.00	15,000.00	6,000.00	6,000.00	6,000.00	6,000.00	464,833.39

TABLE 7.—Expenditures from supplementary funds received from within the States for the year ended June 30, 1939—Continued

Station	Library	Vehicles, tools, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
Indiana.....	\$2,602.30	\$11,192.01	\$5,281.51	\$23,274.76	\$14,757.24	\$26,155.26	\$7,974.36	\$96,390.74	\$462.00	\$266,204.95	\$854,306.02
Iowa.....	4,537.26	4,537.26		14,695.75	885.45	13,139.45	10,846.57	9,930.03	8,694.35	21,793.81	336,319.38
Kansas.....	10,856.92	10,856.92	1,398.34	1,175.53	4,761.75	4,761.09	4,962.38	25,074.47	4,702.72	21,012.85	215,948.81
Kentucky.....	2,492.08	2,492.08	2,479.96	1,357.74	3,617.75	11,835.31	4,513.71	10,428.31	10,428.31	27,996.48	308,922.57
Louisiana.....	126.23	6,415.57	1,013.94	1,312.24	1,026.70	4,576.24	7,930.11	3,250.46	108.31	1,169.07	121,153.65
Maine.....	298.16	3,918.67	735.45	2,210.28	472.88	2,645.67	1,002.77	2,755.24	8,552.81	420.19	84,127.82
Maryland.....	424.89	4,913.65	1,040.99	1,609.80	7,671.74	4,224.05	9,026.50	3,608.31	35.00	36,830.70	165,435.34
Massachusetts.....	666.74	2,038.68	1,172.22	1,609.80	646.78	6,764.56	128.73	9,403.82	171.60		230,243.56
Michigan.....	1,715.96	10,749.46	3,506.52	6,508.82	3,715.08	13,722.53	2,899.06	5,891.08	70.00		335,148.63
Minnesota.....	3,027.19	11,542.92	4,556.35	10,681.53	6,843.23	8,512.60	8,597.41	48,339.23	90.90		544,803.74
Mississippi.....	224.30	9,965.81	1,193.08	1,908.75	1,085.80	3,517.27	2,233.31	6,152.49	5,000.00	26,209.83	185,551.62
Missouri.....	52.30	14,040.60	1,529.17	3,793.12	2,295.89	8,378.82	1,870.48	5,420.01	4,734.57	34,894.32	239,124.69
Montana.....	1,182.43	6,565.75	497.03	504.57	1,137.84	4,250.97	3,320.89	2,322.56	13,729.46		127,534.36
Nebraska.....	267.33	13,091.77	1,564.10	5,624.73	13,150.82	2,984.90	1,463.90	3,504.79	1,457.50		203,822.19
Nevada.....	749.97	511.43	132.35		1,589.75	1,753.15	1,803.69	5,433.19		4,046.49	20,604.85
New Hampshire.....	49.41	9.39	152.62	1,932.67	242.37	1,422.95	102.99	34.64		22,288.37	58,828.17
New Jersey.....	1,103.81	13,540.08		6,069.52		5,316.13	13,619.31	3,550.15	6,478.47	8,039.88	507,417.20
New Mexico.....	115.45	2,378.77	417.23	94.20	45.00	448.93	668.88	298.78	15.00	35,617.46	66,168.93
New York.....	3,133.23	11,242.51	9,708.08	14,650.93	2,943.58	29,626.56	6,903.52	39,230.76	1,377.00		845,583.77
Cornell State.....	1,469.41	1,993.62		3,728.46		8,296.21	56.50	10,867.75	3,358.60		394,316.54
North Carolina.....	30.50	4,457.01	881.00	421.80	1,975.00	4,263.90	266.85	1,070.76	367.50	7,624.22	112,511.89
North Dakota.....	139.61	3,114.16	510.57	736.72	1,245.32	5,027.44	10,001.23	4,025.78		4,752.96	96,392.88
Ohio.....	6,684.54	6,684.54	642.82	7,793.31	3,691.07	5,027.34	2,362.82	4,004.88	4,130.50	356,708.07	864,409.73
Oklahoma.....	1,310.30	10,437.82	2,947.22	3,743.03	14,232.22	7,016.62	2,330.56	16,467.07	1,003.70	18,612.74	388,546.45
Oregon.....	141.53	7,753.14	471.79	5,028.16	2,831.55	14,306.60	4,367.46	5,870.86	5,552.72	184,783.54	510,490.59
Pennsylvania.....	1,549.51	920.38	2,002.71	2,606.54	2,606.54	7,080.92	4,417.64	15,792.20		4,562.05	178,184.26
Puerto Rico.....	6,476.96	1,624.37	3,166.11	3,166.11	3,000.00	2,937.85	162.27	852.27	1,731.33	1,472.96	163,720.15
Rhode Island.....	28.00	6,202.02	35.04	583.00		1,321.51					13,362.14
South Carolina.....	4,392.45	249.71	1,945.81	1,945.81	8,685.91	3,081.14		12,876.36	1,987.27	15,468.42	174,113.89
South Dakota.....	1,399.16	286.83		692.97	4,424.25	1,098.74	84.83	4,492.55	75.00	16,901.39	58,144.67
Tennessee.....	138.15	7,054.69	612.11	727.51	5,181.07	612.94	1,141.26	3,494.55		93,179.10	75,147.03
Texas.....	11,431.04	9,472.36	2,137.29	8,836.99	19,943.99	23,534.12	54,079.96	42,079.92	3,300.00		731,284.69
Utah.....	128.84	1,725.15	317.93	684.02	81.50	2,605.45	4,401.19	181.07	4,218.58	4,450.12	58,912.57
Vermont.....	78.77	680.75	197.84	88.50		1,823.23	470.43	145.22	20.00	699.00	28,056.45
Virginia.....	2,036.24	1,760.93	574.29	1,935.78	3,865.07	7,395.02	771.95	3,423.10	3,140.83		113,284.77
Washington.....	1,098.57	7,649.57	1,512.00	2,084.67	597.75	5,845.87	3,694.55	14,938.70			217,116.45
West Virginia.....	16.20	1,954.71	200.35	965.61	853.07	1,642.19	694.24	1,156.83	3,082.50	6,609.84	84,273.20
Wisconsin.....	256.00	11,978.00	891.00	7,850.00	6,380.00	10,856.00	1,600.00	3,450.00	3,480.00		493,324.00
Wyoming.....		852.57			1,761.07	1,708.45	882.52	476.84	679.37	56,951.32	120,670.48
Total.....	50,192.81	325,311.19	75,417.74	199,128.23	198,371.68	395,261.33	215,666.51	596,040.02	114,882.90	1,684,524.72	14,081,508.61

TABLE 8.—*Experiment station expenditures for additions to equipment for the year ended June 30, 1939*

Station	Buildings	Library	Apparatus	Farm im- plements	Livestock	Total
Alabama.....	\$25,887.92	\$1,042.43	\$7,775.32	\$9,207.71	\$10,379.82	\$55,293.20
Alaska.....	120.00	10.75	5.60	2,253.68	780.00	3,170.03
Arizona.....	3,376.16	41.46	3,031.12	2,176.45	190.80	9,815.99
Arkansas.....	8,777.63	941.45	4,664.84	2,971.90	1,317.43	18,673.25
California.....	68,833.19	5,194.96	15,584.87	31,169.74	19,481.09	140,263.85
Colorado.....		74.47	4,884.24	3,937.66	8,730.98	17,627.35
Connecticut:						
State.....		1,740.42	1,280.32	3,560.19	255.00	6,835.93
Storrs.....		1,207.46	914.54	253.02	138.32	2,513.34
Delaware.....		1,072.69	2,466.90	2,404.42	291.68	6,235.69
Florida.....	7,137.37	2,657.58	13,673.33	19,843.17	2,786.05	46,097.50
Georgia.....	8,756.43	1,377.58	1,706.24	9,636.27	11,391.03	32,867.55
Hawaii.....	5,391.12	100.68	4,713.10	904.55	150.00	11,259.45
Idaho.....	879.74	356.34	2,634.62	2,119.87	1,005.10	6,995.67
Illinois.....		34.81	9,749.74	13,591.29	1,930.00	25,305.84
Indiana.....	75,417.87	2,632.80	34,619.12	12,481.33	14,859.24	140,010.36
Iowa.....	9,791.78		14,835.24	4,672.51	835.45	30,134.98
Kansas.....	24,827.81	311.04	4,009.10	12,597.41	5,464.81	47,810.17
Kentucky.....		2,442.09	12,579.28	3,097.31	361.75	18,480.43
Louisiana.....	807.68	137.01	4,029.65	9,179.48	1,403.90	15,587.72
Maine.....		1,332.46	2,766.59	7,029.19	880.10	12,008.34
Maryland.....	5,042.10	454.93	5,695.43	7,217.80	7,884.04	26,294.30
Massachusetts.....	8,526.18	856.80	2,569.24	2,219.33	839.80	15,011.35
Michigan.....	2,700.94	1,769.98	13,652.19	11,423.16	3,715.08	33,261.35
Minnesota.....	7,074.71	3,048.27	14,338.27	11,936.42	7,507.22	43,904.89
Mississippi.....	5,417.86	335.86	7,935.91	16,517.94	2,210.86	32,418.43
Missouri.....	4,126.09	90.40	10,626.67	16,093.42	2,380.64	33,317.22
Montana.....		1,239.06	1,873.23	7,961.52	1,137.84	12,211.65
Nebraska.....		314.91	9,501.36	14,585.28	13,325.82	37,727.37
Nevada.....	552.05	817.12	836.36	864.80	3,813.33	6,883.66
New Hampshire.....	587.58	709.32	5,415.04	10.64	249.37	6,971.95
New Jersey.....		1,488.67	9,860.71	14,790.31	47.87	26,187.56
New Mexico.....	450.00	178.95	3,803.18	2,925.29	2,005.65	9,363.07
New York:						
Cornell.....	19,669.33	3,273.41	24,390.91	14,996.61	3,785.78	66,116.04
State.....		1,080.85	3,562.06	288.12		4,931.03
North Carolina.....	251.26	70.42	5,669.88	6,020.75	2,145.60	14,157.91
North Dakota.....		569.47	5,558.32	7,008.89	2,555.74	15,692.42
Ohio.....		529.18	14,971.34	12,913.49	23,580.92	51,994.93
Oklahoma.....	13,592.27	1,330.91	15,748.13	12,218.71	15,851.93	58,741.95
Oregon.....	2,319.08	163.17	5,870.75	7,812.82	9,281.55	25,447.37
Pennsylvania.....			5,738.04	3,624.24	3,264.61	12,626.89
Puerto Rico.....	18,916.84	1,076.68	12,567.17	7,610.39	360.00	40,531.08
Rhode Island.....	331.42	183.78	1,057.99	1,317.29		2,890.48
South Carolina.....	2,012.76	1,039.13	4,973.45	9,830.29	9,135.16	26,990.79
South Dakota.....	1,360.42	884.68	2,681.58	2,325.42	6,670.07	13,922.17
Tennessee.....	4,280.24	800.68	4,831.42	12,598.43	8,613.30	31,124.07
Texas.....	48,344.48	11,674.32	17,463.51	10,661.94	20,243.29	108,387.54
Utah.....		173.74	1,734.29	2,559.09	144.00	4,611.12
Vermont.....		294.23	3,141.38	2,190.46		5,626.07
Virginia.....	2,109.61	2,086.84	9,374.49	3,809.18	3,900.04	21,280.16
Washington.....	3,573.09	1,437.85	5,191.86	8,842.60	1,058.82	20,104.22
West Virginia.....		51.14	5,589.09	3,630.40	2,525.29	11,795.92
Wisconsin.....	2,770.00	256.00	7,925.00	11,978.00	6,380.00	29,309.00
Wyoming.....		99.24	1,551.98	1,640.48	2,564.87	5,856.57
Total.....	395,013.01	61,088.47	392,223.99	404,510.66	249,811.04	1,502,647.17

TABLE 9.—Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, Mar. 16, 1906, Feb. 24, 1925, May 16, 1928, Feb. 23, 1929, June 29, 1935, and June 20, 1936

State or Territory	Hatch Act		Adams Act		Purnell Act		Bankhead-Jones Act	
	1888-1938	1939	1906-38	1939	1926-38	1939	1936-38	1939
Alabama.....	\$763,946.42	\$15,000.00	\$461,619.89	\$15,000.00	\$680,000.00	\$60,000.00	\$124,042.68	\$72,358.23
Alaska.....	105,000.00	15,000.00	7,500.00	7,500.00	1,250.00	1,250.00	3,354.72	1,804.06
Arizona.....	729,803.10	15,000.00	464,955.61	15,000.00	680,000.00	60,000.00	18,633.84	10,869.74
Arkansas.....	763,139.12	15,000.00	464,900.00	15,000.00	680,000.00	60,000.00	95,974.80	55,985.30
California.....	765,000.00	15,000.00	464,926.84	15,000.00	680,000.00	60,000.00	98,912.94	57,699.21
Colorado.....	764,718.82	15,000.00	463,638.93	15,000.00	680,000.00	60,000.00	33,646.44	19,627.09
Connecticut.....	763,000.00	14,934.06	463,000.00	15,000.00	680,000.00	59,932.33	30,987.12	18,046.94
Dakota Territory.....	56,250.00							
Delaware.....	763,352.87	15,000.00	460,475.12	15,000.00	676,924.01	60,000.00	7,515.30	4,383.93
Florida.....	764,966.04	15,000.00	464,996.06	15,000.00	676,523.74	60,000.00	46,202.46	26,951.43
Georgia.....	760,593.43	15,000.00	452,092.87	15,000.00	680,000.00	60,000.00	131,284.38	76,582.56
Hawaii.....	134,919.17	15,000.00	89,951.14	15,000.00	40,000.00	25,000.00	13,779.60	8,038.10
Idaho.....	680,324.13	15,000.00	460,812.22	15,000.00	680,000.00	60,000.00	20,577.84	12,003.74
Illinois.....	763,164.39	15,000.00	464,794.66	14,994.31	677,445.71	60,000.00	129,786.53	75,894.45
Indiana.....	764,901.19	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	91,846.43	54,882.28
Iowa.....	765,000.00	15,000.00	465,000.00	15,000.00	677,965.17	60,000.00	97,281.96	56,747.81
Kansas.....	764,995.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	75,076.44	43,794.59
Kentucky.....	764,996.57	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	118,407.06	69,070.78
Louisiana.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	82,700.16	48,241.76
Maine.....	764,999.62	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	31,038.24	18,105.64
Maryland.....	764,967.40	15,000.00	464,236.48	15,000.00	680,000.00	60,000.00	42,825.72	24,981.67
Massachusetts.....	764,617.70	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	27,273.30	15,909.43
Michigan.....	764,676.10	15,000.00	461,341.20	15,000.00	680,000.00	60,000.00	100,451.76	58,596.86
Minnesota.....	764,917.78	15,000.00	464,345.00	15,000.00	680,000.00	60,000.00	85,196.46	49,697.93
Mississippi.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	108,977.10	63,569.98
Missouri.....	760,097.24	15,000.00	464,999.90	15,000.00	680,000.00	60,000.00	115,451.70	67,346.82
Montana.....	675,000.00	15,000.00	462,417.04	15,000.00	680,000.00	60,000.00	23,254.74	13,565.27
Nebraska.....	764,932.16	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	58,164.90	33,929.52
Nevada.....	764,214.32	15,000.00	463,180.28	15,000.00	680,000.00	60,000.00	3,690.96	2,153.06
New Hampshire.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	12,535.80	7,312.55

New Jersey.....	764,949.97	15,000.00	464,392.06	15,000.00	680,000.00	60,000.00	45,788.76	26,710.11
New Mexico.....	729,509.05	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	20,641.50	12,040.88
New York.....	764,757.18	15,000.00	464,187.18	15,000.00	679,904.16	60,000.00	134,747.34	78,602.68
North Carolina.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	153,942.00	89,799.50
North Dakota.....	706,502.26	14,998.73	464,638.85	14,998.32	679,994.14	59,999.72	37,013.63	21,585.03
Ohio.....	765,000.00	15,000.00	463,514.02	15,000.00	680,000.00	60,000.00	139,522.14	81,387.92
Oklahoma.....	689,002.16	15,000.00	444,535.19	15,000.00	680,000.00	60,000.00	102,676.26	59,894.48
Oregon.....	750,156.64	15,000.00	460,000.00	15,000.00	680,000.00	60,000.00	30,263.70	17,653.83
Pennsylvania.....	764,967.43	15,000.00	464,995.41	15,000.00	680,000.00	60,000.00	202,034.28	117,853.33
Puerto Rico.....	59,802.84	14,997.04	48,802.36	14,932.17	14,782.24	11,846.36	67,970.58	40,342.84
Rhode Island.....	764,999.65	15,000.00	459,423.07	15,000.00	679,974.35	60,000.00	3,395.76	1,980.86
South Carolina.....	764,542.15	15,000.00	463,660.12	15,000.00	680,000.00	60,000.00	80,197.44	52,031.84
South Dakota.....	708,250.00	15,000.00	460,000.00	15,000.00	680,000.00	60,000.00	30,948.06	21,373.83
Tennessee.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	112,173.82	65,133.90
Texas.....	765,000.00	15,000.00	462,592.26	15,000.00	680,000.00	60,000.00	223,047.14	130,694.16
Utah.....	630,000.00	15,000.00	464,821.94	15,000.00	680,000.00	60,000.00	15,755.52	9,190.72
Vermont.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	15,707.40	9,162.65
Virginia.....	762,824.12	15,000.00	464,949.01	15,000.00	679,994.27	60,000.00	106,716.84	62,251.49
Washington.....	702,102.65	15,000.00	461,980.11	15,000.00	680,000.00	60,000.00	44,273.58	25,826.26
West Virginia.....	764,793.83	15,000.00	462,013.52	15,000.00	679,942.89	60,000.00	80,720.16	47,086.76
Wisconsin.....	765,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	90,337.32	52,696.77
Wyoming.....	750,000.00	15,000.00	465,000.00	15,000.00	680,000.00	60,000.00	10,135.28	5,914.58
Total.....	36,399,684.20	764,989.83	22,379,618.64	757,429.80	32,083,450.71	2,918,028.41	3,592,886.49	2,097,671.70



ADDRESS LIST OF AGRICULTURAL EXPERIMENT STATIONS

- ALABAMA.—*Auburn*, M. J. Funchess, Director.
ALASKA.—*College*, L. T. Oldroyd, Director.
ARIZONA.—*Tucson*, P. S. Burgess, Director.
ARKANSAS.—*Fayetteville*, W. R. Horlacher, Director.
CALIFORNIA.—*Berkeley*, C. B. Hutchison, Director.
COLORADO.—*Fort Collins*, I. E. Newsom, Acting Director.
CONNECTICUT.—*New Haven*, W. L. Slate, Director; *Storrs*, W. L. Slate, Director.
DELAWARE.—*Newark*, G. L. Schuster, Director.
FLORIDA.—*Gainesville*, Wilmon Newell, Director.
GEORGIA.—*Experiment*, H. P. Stuckey, Director.
HAWAII.—*Honolulu*, J. H. Beaumont, Director.
IDAHO.—*Moscow*, E. J. Iddings, Director.
ILLINOIS.—*Urbana*, H. P. Rusk, Director.
INDIANA.—*La Fayette*, H. J. Reed, Director.
IOWA.—*Ames*, R. E. Buchanan, Director.
KANSAS.—*Manhattan*, L. E. Call, Director.
KENTUCKY.—*Lexington*, T. P. Cooper, Director.
LOUISIANA.—*University*, C. T. Dowell, Director.
MAINE.—*Orono*, F. Griffee, Director.
MARYLAND.—*College Park*, T. B. Symons, Acting Director.
MASSACHUSETTS.—*Amherst*, F. J. Sievers, Director.
MICHIGAN.—*East Lansing*, V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul*, W. C. Coffey, Director.
MISSISSIPPI.—*State College*, Clarence Dorman, Director.
MISSOURI.—*Columbia*, M. F. Miller, Director.
MONTANA.—*Bozeman*, Clyde McKee, Director.
NEBRASKA.—*Lincoln*, W. W. Burr, Director.
NEVADA.—*Reno*, S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham*, M. G. Eastman, Director.
NEW JERSEY.—*New Brunswick*, W. H. Martin, Director.
NEW MEXICO.—*State College*, Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), P. J. Parrott, Director; *Ithaca* (Cornell Station) C. E. Ladd, Director.
NORTH CAROLINA.—*State College Station, Raleigh*, I. O. Schaub, Acting Director.
NORTH DAKOTA.—*State College Station, Fargo*, H. L. Walster, Director.
OHIO.—*Wooster*, Edmund Secrest, Director.
OKLAHOMA.—*Stillwater*, W. L. Blizzard, Director.
OREGON.—*Corvallis*, W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College*, S. W. Fletcher, Director.
PUERTO RICO.—*Mayaguez* (Federal Station), Atherton Lee, Director; *Rio Piedras* (College Station), J. A. B. Nolla, Director.
RHODE ISLAND.—*Kingston*, B. E. Gilbert, Acting Director.
SOUTH CAROLINA.—*Clemson*, H. P. Cooper, Director.
SOUTH DAKOTA.—*Brookings*, I. B. Johnson, Director.
TENNESSEE.—*Knowville*, C. A. Mooers, Director.
TEXAS.—*College Station*, A. B. Conner, Director.
UTAH.—*Logan*, R. H. Walker, Director.
VERMONT.—*Burlington*, J. L. Hills, Director.
VIRGINIA.—*Blacksburg*, A. W. Drinkard, Jr., Director.
WASHINGTON.—*Pullman*, E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown*, C. R. Orton, Director.
WISCONSIN.—*Madison*, C. L. Christensen, Director.
WYOMING.—*Laramie*, J. A. Hill, Director.

NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.

